The distribution of **Renewable Energy Technology** through livestock markets in Kenya's pastoralist areas

a contingent valuation study

August 8, 2012

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Research Project | 468017

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SNV Connecting People's Capacities

VU UNIVERSITY AMSTERDAM


KENYA

Abstract

Around 2 billion people worldwide suffer from energy poverty. This means lack of access to modern energy facilities hampers their socio-economic development. Most households in Kenya, especially in rural areas, rely on biomass for cooking and kerosene for lighting. These fuels come with significant health, as well as environmental impacts and negatively affect the welfare of especially the rural poor. Adoption of Renewable Energy Technology (RET), such as Improved Cookstoves (ICS) and Photovoltaic Solar Lanterns (PSL) can bring a range of benefits to the Bottom-Of-the-Pyramid (BOP). This research looks into the potential of economically viable dissemination of RET through livestock markets, to the most vulnerable communities in rural Kenya. By means of observation studies, quantitative and qualitative data collection and Contingent Valuation Method (CVM) in three locations, the demand for RET was assessed. Moreover, the barriers for distribution were determined. According to the results of this study, secondary livestock markets could be suitable distribution points for both PSL and ICS. A considerable 28% of respondents indicated a WTP for either ICS or PSL that exceeded the retail price. However, considering the substantial capital costs of the ICS and PSL products referred to in this study and the welfare of visitors of the livestock market, it seems questionable whether this distribution strategy will, in fact, target the BOP.

Acknowledgements

The writing of this thesis was something I could not have done without the help of certain people. Hereby I would like to thank my external supervisor Jechoniah Kitala at SNV in Kenya, my supervisors Ellisaios Papyrakis and Pieter van Beukering at VU University, Bianca van der Kroon and Rahul Barua for their enthusiasm and support, and Anna Ingwe at GIZ in Nairobi.

Preface

The RENEW IS-Academy is a collaborative five-year research program on energy access and development cooperation in East Africa. The Institute for Environmental Studies (IVM) works together with the Dutch Ministry of Foreign Affairs (DGIS) and the Energy research Centre of the Netherlands (ECN) on developing practically oriented studies that aims to construct theoretical perspectives on decision making, business models and technological innovation systems.

In order to complete research for the RENEW-IS Academy the author spent eight weeks in Kenya with SNV (Netherlands Development Organization) on internship. SNV is an NGO largely funded by the Dutch government. SNV focuses on increasing access to basic services, alleviating poverty and increasing employment in developing countries. The organization centers on three spear points: effectiveness, connectivity and scalability. A primary focal point revolves around leveraging critical mass: in other words, SNV aims to build hedonistic strategies that target a large audience.

As part of its aspirations to work with local actors SNV is providing support to React Africa, an independent, Nairobi-based, consultancy agency that offers a variety of services related to sustainable entrepreneurship. These services range from promoting fair trade to providing trainings on governance, management and addressing gender issues. In addition, React Africa is now looking into the distribution of Renewable Energy Technology.

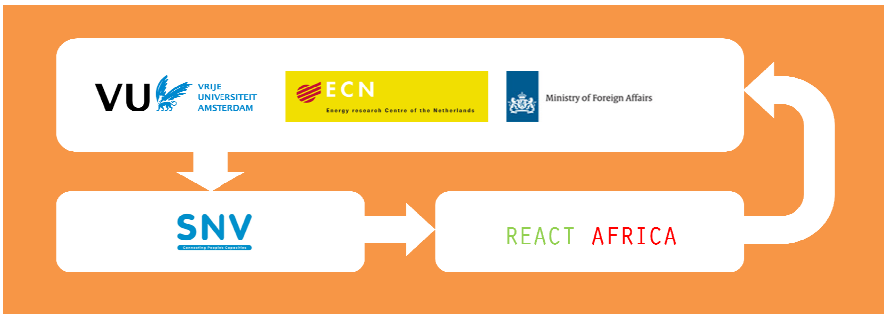

Figure 1: Feedback process (drawn up by the author)

This dissertation aims to touch upon a range of research topics so as to deliver tangible results to all actors involved in this project. The scheme above presents the feedback loop that helped to structure this study (Figure 1). The project started out with demands formulated by different parties from the RENEW IS-Academy (VU University, ECN, DGIS). Next SNV and React Africa, in this order, gave input. Lastly, a research proposal was written that was again assessed by all actors before finalization.

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List of Abbreviations

BOP - Bottom of the Pyramid

CDM - Clean Development Mechanism

DGIS - Directive General for International Cooperation, Dutch Ministry of Foreign Affairs

DV - Dependent variable

ECN - Energy research Centre of the Netherlands

GHG - Greenhouse gas

GIZ - The German Society for International Cooperation

GOK - Government of Kenya

IAP - Indoor air pollution

IEA - International Energy Agency

IFC - International Finance Corporation

IV - Independent variable

IVM - Institute for Environmental Studies, VU University Amsterdam

KML - Kenyan Ministry of Livestock

KSh - Kenyan Shilling

LA - Lighting Africa program

LED - Light emitting diode

MDG - Millennium Development Goal

NGO - Non-governmental organization

PM_{10} - Particulate matter with diameter of 10 microns or less

POS - Point of sale

PV - Photovoltaic

RET - Renewable Energy Technology

SACCO - Savings And Credit Co-operative

SHS - Solar Home System

SSA - Sub-Saharan Africa

UN - United Nations

1. Introduction

In 1981 world leaders gathered for a United Nations (UN) conference in Nairobi, Kenya, to discuss a systems change towards the adoption of new and renewable energy. While some progress has been made since then, today 26% of the world's population still has no access to electricity. This amounts to around 2 billion people in total (Mahapatra et al., 2009). Lack of access to safe, clean and affordable energy is a barrier for social and economic development (Dutta, 2004). We refer to this issue with the term 'energy poverty'. In 2000, the UN recognized their Millennium Development Goals (MDGs) cannot be met without promoting access to clean and affordable energy in developing countries.

Among malnutrition, AIDS and absence of clean drinking water, dependency on biomass fuels for cooking is one of the main causes of death in Sub-Saharan Africa (SSA) (Figure 2) (Birol, 2007). Yearly around 1.3 million people die from health complications related to bad indoor air quality, caused primarily by inefficient combustion of biomass for cooking (WHO, 2006). Mostly women and small children, who spend more time indoors and around the cookstove, are affected (Dutta, 2005). Moreover, the large-scale consumption of firewood is linked to deforestation and climate change. For indoor lighting, the majority of households in developing countries such as Kenya rely on kerosene (also known as paraffin) lanterns, which not only contribute to indoor air pollution, they are also a poor source of light and come with high fuel costs. With the world population growing, poverty increasing and a lack of alternative energy solutions the demand for biomass fuels and kerosene keeps growing (Kiplagat et al., 2011).

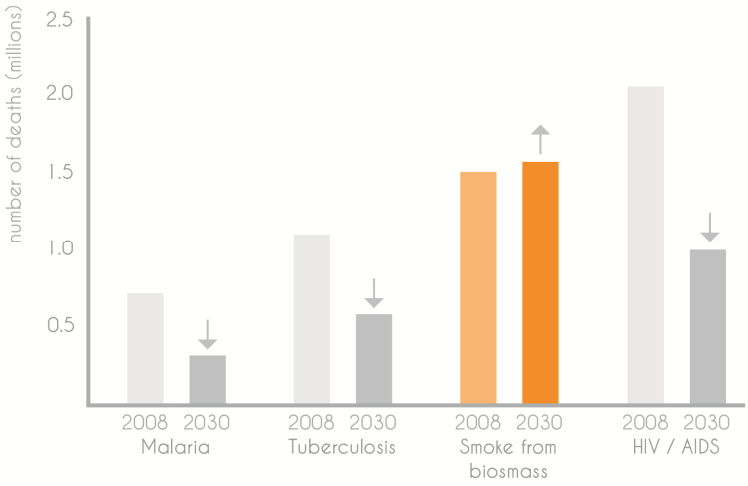

Figure 2: Number of premature deaths from IAP-related health impacts (source: IEA; WHO, 2010)

Adoption of Renewable Energy Technology (RET) can help counteract energy poverty. RET has the potential to improve health and livelihoods of especially rural households in developing countries, as well as reduce environmental impacts (World bank, 2011). SNV aims to promote RET among the rural poor throughout Kenya. In order to do so however, the right channels for large-scale distribution need to be determined.

It was hypothesized that livestock markets might be suitable points of sale for RET to Kenya's Bottom-Of-the-Pyramid (BOP) in rural, pastoralist areas. In order to assess the potential of this distribution model it is necessary to complete a thorough assessment of the market and the demand for RET. The overarching research question will be:

> *What is the potential for the economically viable distribution of Renewable Energy Technology to the Bottom-of-the-Pyramid in Kenya's pastoralist areas?*

This dissertation will focus on a range of subjects in order to complete a thorough research: it studies the livestock markets context and aims to construct a consumer profile. Moreover, it will attempt to explore the energy use, energy needs, awareness of and the demand for RET in Kenya's rural, pastoralist areas. The following sub-questions were compiled to further analyze the determinants for the adoption of RET by Kenya's BOP:

1. *What is the current status of energy access in Kenya's pastoralist areas ?*
2. *What are the characteristics of livestock markets in Kenya's pastoralist areas?*
3. *What are the socio-economic characteristics of visitors of livestock markets in Kenya's pastoralist areas?*
4. *To what extent is the target consumer familiar with RET and its benefits?*
5. *What is the likelihood that the potential consumer will invest in Renewable Energy Technology?*

The main RET this research will focus on are Improved Cookstoves (ICS) and Photovoltaic Solar Lanterns (PSL), since these are products React Africa aims to distribute. Both ICS and PSL provide off-grid energy solutions, comprise fairly basic technology and are available in a reasonably low price range. ICS are designed to maximize fuel efficiency and thus reduce fuel usage and toxic emissions.

PSL make use of LEDs to provide high-quality lighting. The integrated battery is charged by sunlight, so households no longer have to dependent on kerosene.

The novelty of this thesis will lie in exploratory research into the feasibility of livestock markets as potential distribution points for RET. To the best knowledge of the author, little or no research has been done in connecting RET distribution networks to livestock markets. A strategy based on the hypothesis that livestock markets might be suitable *points of sale* has the potential to efficiently target BOP households across Kenya. Furthermore, this research aims to provide an insight into the behavior, livelihoods and needs of Kenyan pastoralist households in different areas.

This dissertation comprises 5 chapters. It sets out with literature research in chapter 2 wherein the benefits of RET and potential market barriers for distribution will be discussed. Moreover, this chapter encompasses a section on livestock and livestock markets. Chapter 3 then elaborates on the methodology of this research. Chapter 4 will go into the results and discussion section from field work research. Lastly, in Chapter 5 the reader will find the conclusions from this research, as well a recommendations section for the distribution of Renewable Energy Technology through livestock markets in Kenya's pastoralist areas.

2. Literature review

2.1 Kenya: geographic, economic and demographic information

Kenya is located on the equator, on the East side of the African continent. It is bordered by Somalia, Ethiopia and Sudan to the North, Uganda to the West, and Tanzania to the East. Its coastal side, to the east, is connected to the Indian Ocean. The climate in Kenya differs per region, but is generally tropical, with an average temperature of around 22°C (Kiplagat et al., 2011).

The population comprises a little over 43 million people, of which 42.2% is below the age of 14. Kenya's population is exceptionally young, with an average age of 18.9 years. HIV/aids is the main cause of death in Kenya; about 6.8% of all citizens are infected (CIA factbook, 2011). Life expectancy at birth is 56 years (World Bank, 2011).

Kenya is a hub for trade and finances in Eastern Africa and one of the leading economies in the region. 75% of the labor force is dedicated to agriculture (CIA factbook, 2011). While education and literacy rates are high (85.5%) compared to other Eastern African countries, Kenya still has an official unemployment rate of 40%. Van den Berg and Schipper (2012) report that, in 2006, 45.9% of the population was living below the poverty line.

2.2 Energy Access in SSA and Kenya

Energy is an essential factor for social development and the key driver for industrialization and economic growth (Brew-Hammond, 2010). Kebede et al. (2010) pose that the absence of high-quality energy facilities is directly connected with a range of poverty indicators, such as illiteracy, life expectancy and child mortality.

Access to electricity in SSA is generally low. SSA houses 13% of the world's population, but is only responsible for 2% of the world's total energy consumption (Kebede et al., 2010). In Eastern Africa electrification rates differ per region, with an average of 40% and 5% for urban and rural household respectively (Brew-Hammond, 2009). Overall access to electricity in Kenya is not more than 15% and

as low as 4% in rural areas (Abdullah and Markandya, 2011; Bailis et al., 2006). In many cases electricity, where it is available, is unreliable: both blackouts as well as brownouts[1] occur frequently.

For generating grid electricity Kenya mainly relies on hydropower, thermal and geothermal energy. Remarkably enough, the amount of renewable energy contributing to the total amount of electricity produced adds up to around 80% (Parshall et al., 2011). However, this is only a small part of all energy consumed. Moreover, only 10.9% of all consumed energy is locally produced[2]. Kenya relies heavily on foreign oil. In 2008 36% of Kenya's total import budget was dedicated to petroleum (Kiplagata et al., 2011). Modern energy services, like petroleum fuels and electricity, are mainly accessed by the commercial, agricultural and industrial sectors. Still, even with extensive petroleum imports insufficient amounts of energy are generated: Kenya is known to regularly have energy rationing (Karekezi, 2002).

In Kenya, and most SSA countries, around 85% of all households rely on traditional biomass for cooking, such as wood, charcoal and agricultural residues (Figure 3). For lighting people mostly rely on kerosene (also known as paraffin), both in urban and rural contexts. According to Kiplagat et al. (2011) around 94% of rural households use kerosene lanterns for lighting their dwellings.

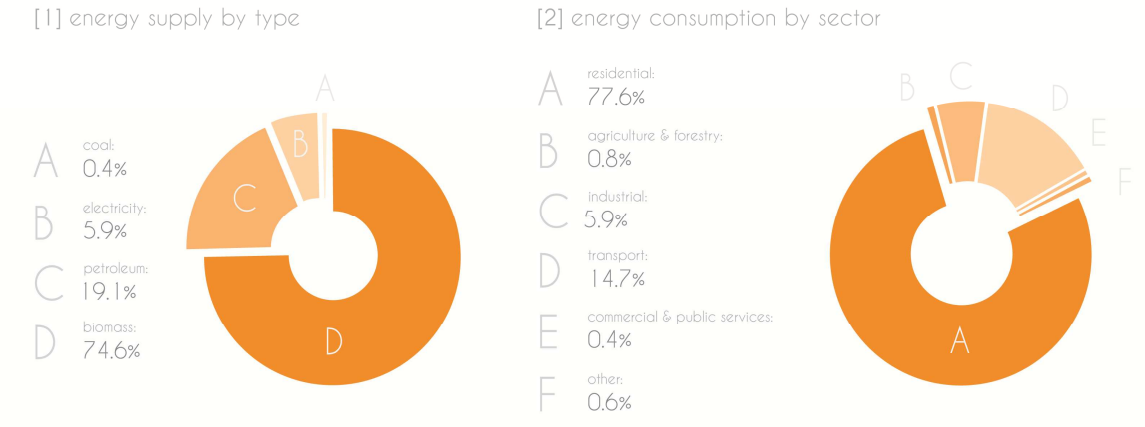

Figure 3: Statistics graph of energy in Kenya (source: graphs based on Kiplagat et al., 2011)

[1] Drop in electricity voltage

[2] Data from 2007

Projections are that over the next 25 years the amount of people relying on traditional fuels will grow (Brew-Hammond, 2010). Especially in Kenya's rural areas it has been proven hard to find funds to invest in electrification, since both capital and operational costs per household are profoundly higher than in urban areas. Moreover, both income and energy consumption in rural areas is lower, further complicating this issue and making it a less lucrative activity as seen from the supply side (Abdullah and Markandya, 2011).

On the other hand, in Kenya there is high potential for tapping into renewable energy resources. The country is already generating around 740 MW yearly in both large and small hydropower generators (Kiplagat et al., 2011. Kenya daily receives a great amount of solar energy, ranging from 4 kWh/m2/day up to 6 kWh/m2/day in some areas, which amounts to around 250 million tons of oil equivalent per day. Thus solar energy might be a valuable resource. Solar energy can be used for thermal as well as for photovoltaic (PV) energy. The latter form can be allocated for powering electrical products, such as solar lanterns, without the necessity for traditional electrical infrastructure. The Government of Kenya (GOK) is investing in programs distributing solar electrification products to schools and public buildings in remote areas. Over the last years more and more people have started adopting PV solar panels. Today, more households in Kenya than anywhere in the world own a solar product (Kiplagat et al., 2011)

Recently the GOK installed a feed-in tariff policy for energy production through small hydro projects, wind and biomass resources in order to attract more private sector investments so as to diversify the sources that contribute to the national power supply. The policy forces energy distributers to purchase renewable energy on a priority basis and provides the supplier with a fixed tariff in return (GOK, 2012).

2.3 The benefits of Renewable Energy Technology

RET might provide the solution for alleviating energy poverty among the BOP in SSA. Especially in rural areas, where electrification rates are low, RET can help improve livelihoods and reduce health impacts of households. This sub-section sets out to discuss the benefits of ICS and PSL and looks into the dangers of traditional cooking and lighting in rural Kenya (Figure 4).

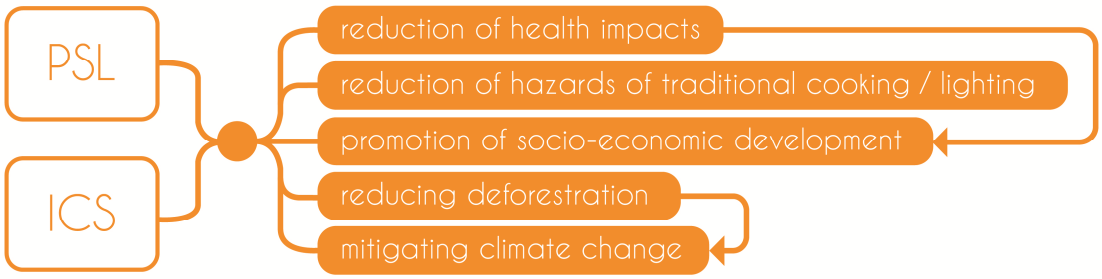

Figure 4: Benefits of RET (drawn up by the author)

2.3.1 Reduction of indoor air pollution

In SSA, cooking is the main cause of indoor air pollution (IAP) (Torres-Duge et al., 2008). Traditional cooking setups, like cooking over a three-stone open fire (Figure 5), are inefficient for burning biomass fuels and lead to incomplete combustion processes. Inhalation of the toxic smoke can lead to severe health impacts. Among others pollutants like harmful particulate matter (PM_{10}), volatile organic compounds (VOCs) carbon monoxide (CO), sulphur oxide (SO_2) and nitrous oxides are emitted (Bailis et al., 2009). Bad ventilation contributes to the fact that pollutant levels in the indoor environment in developing countries frequently exceed health standards, in both living and sleeping areas. Estimations say that IAP, in total, was associated with over 1.6 million deaths in 2000, which adds up to almost 5% of total mortality worldwide (Ezzati, 2004).

Figure 5: Three-stone open fire (source: picture taken by the author)

Women and children spend most time indoors and around the cookstove, they are therefore most affected. Inhalation of biomass smoke is associated with a range of illnesses, including chronic pulmonary disease, lung cancer, tuberculosis (tbc), eye deceases, acute lower reparatory deceases (ALRI's) (e.g. pneumonia among very young children) and low birth weights. Globally ALRI's are the main cause of death for children under the age of five (Bailis et al., 2009).

Besides cooking, lighting and heating are activities that contribute to IAP. Kerosene-based lanterns, that are the most common devices used for indoor lighting, mainly use fuel for the production of waste heat instead of light. Since the light is of poor quality, one tends to move close to the lantern, which increases the threat of inhaling more of the kerosene fumes. These fumes contain harmful components, such as CO, NO_x, SO_x and VOCs (Pode, 2010). There is evidence inhalation of these fumes can lead to respiratory deceases, throat and lung cancer, eye complications and infections and low birth weights (Torres-Duge et al., 2008).

Modern, efficient fuels produce a large amount of useful energy and little pollutants[3]. However they are generally more expensive. The energy ladder theory describes the relationship between fuel choice and welfare: as income or status increases a shift in household fuel choice is likely to occur towards more sophisticated fuels (Torres-Duge et al., 2008). PSL and ICS can benefit the welfare and health of households that cannot afford high-quality fuels.

ICS are technologically designed to burn biomass fuel efficiently and under the right conditions so as to minimize the production of harmful byproducts in the combustion process. The new generation ICS bring down emissions up to 50% (World Bank, 2012). PSL eliminate the need for kerosene fuels, since they rely on solar energy. This means PSL do not produce any damaging emissions.

2.3.2 Hazards of traditional cooking and lighting

In developing countries, the traditional setups for lighting and cooking can pose a serious threat to the wellbeing of households. When indoor cooking and lighting are not done with the right equipment fire safety becomes a serious issue. An estimated amount of 98% of all lethal burn victims occur in developing nations (Peck et al., 2008). In Kenya, the poorest households live in

[3] examples are LPG, biofuels or electricity

rudimentary homes that are made with basic materials. In urban areas, where houses are built closely to each other, the fire hazard is even greater.

In the rudimentary houses of rural Kenya, flames can rapidly get into contact with fabrics or other flammable (construction) materials. One study looked into the impacts of a simulated fire in a South African 'shack', triggered by a tipped over kerosene stove that has been burning for 1 hour. Within 4 minutes the inside temperature rose to 900 °C (Peck et al., 2008).

Since households in developing countries often include many members, dwellings are often crowded. This brings the risk that stoves can tip over or that people suffer from burns caused by direct contact with the stove. Especially children injure themselves in this way (Victor 2011). Peck et al. (2008) pose that "burns caused by homemade bottle lamps or commercial wick lamps are a cause of major morbidity and mortality in developing nations" (p. 308). Lanterns can easily be toppled over or cause burns when adding more fuel.

RET can provide a safer alternative to cooking and lighting. ICS are safer to use than traditional stoves: they are more robustly built and since they are well insulated to direct heat their surface gets less hot when used. In contrast to kerosene lanterns, PSL use electrical energy. This means the risk of fire hazard is reduced dramatically.

2.3.3 Promotion of socio-economic development

While households in SSA use little energy by comparison they spend a considerate amount of their monthly budget on it. Abdullah and Markandya (2012) present data that reveal that the non-electrified households in the district of Kisumu, Kenya, spend up to 21% of their total expenditure on energy, while according to the authors the budgetary limit should lie around 10%. This means households could save over one-tenth on their total budget, if only modern, affordable energy services were available to them.

Since women and children are primary responsible for fuelwood collection this to a large extent hampers their socio-economic development (Figure 6). This traditional allocation of household tasks contributes greatly to gender inequality and the fact that women are less educated than men (Schlag and Zuzarte, 2008). Studies by the International Energy Agency (IEA) show that the average weight of

bundles of firewood carried by women is 20 kg (Schlag and Zuzarte, 2008). One study among 14 SSA countries reveals households spend between 0.33 and 4 hours collecting biomass fuels every day (World Bank, 2011). There are considerable opportunity costs connected this activity: women all over SSA give up opportunities for self-development, education or income generating activities since they have little free time.

Figure 6: Children often spend large amounts of time gathering firewood (source: flickr.com)

Kerosene is expensive. Even though the Kenyan government has exempted kerosene from a number of taxes[4] on petroleum fuels, the price of kerosene remains high, especially in rural areas, due to distribution and retail costs (Kiplagat et al., 2011). Even compared to electric lighting the cost of useful light energy from a kerosene wick lamp in rural Kenya is 325 as high as that of an (inefficient) incandescent light bulb (Pode, 2010).

Besides being costly, kerosene lanterns provide very poor lighting which makes working or taking care of children after dark difficult. Depending on the type, the light output ranges from 10 to 100 lumen, which is very meager compared to the 600 lumen of an average PSL (Mahapatra, 2009).

[4] Kerosene was exempted from a number of petroleum taxes in order to reduce deforestation impacts caused by overconsumption of fuelwood

So, we have seen how poor access to modern energy facilities has direct impacts on health and welfare. Datta (2005) describes how access to modern energy can eradicate extreme poverty and hunger: with less time spent on gathering firewood or acquiring charcoal, households now have more time to spend to study or gather income. This means they can be more productive, can get better education, take better care of themselves and of their family members. The graph presented in appendix A further clarifies this topic.

ICS facilitates fuel reductions, which means less time has to be spend on gathering fuel wood. This will counteract gender inequality and enables especially women and children to spend more time studying or generating income. Households that pay for fuel will attain considerable reductions in their expenses. Some studies report savings in expenditure of between 20-50% (Dutta, 2004). These savings can partly be attributed to savings in healthcare expenses, due to the fact that ICS promotes a healthier indoor environment.

The adoption of PSL also has great potential to promote social and economic development, considering that today most household in developing countries rely on kerosene lanterns. While purchasing PSL requires an initial investment, it eliminates spendings on fuel, which can result in an increase in monthly savings of up to 70% (Pode, 2010). PSL brings almost limitless hours of high-quality lighting that enables households to work or study longer hours. The fact that the lighting is of much higher quality also contributes to higher productivity and an overall higher quality of living. Lastly, the health benefits of RET will lead to less medical expenses and thus more monetary savings.

2.3.4 Reducing Deforestation

Biomass consumption for energy purposes can result in severe forms of deforestation and degradation of woodland resources such as soil erosion (Bailis et al., 2003). The benefits of maintaining forest cover include preserving biodiversity, carbon sequestration (see next chapter), prevention of soil depletion and to be able to produce (economically lucrative) natural resources.

The current yearly deforestation rate in Africa is around 0.6% (Schlag and Zuzarte, 2008). Due to lack of reliable data it is hard to say to what extent exploitation of biomass fuels in Kenya is resulting in permanent deforestation (Bailis et al., 2006). While skeptics say this not necessarily the case, Kenya's environmental community seems to agree on the negative effects (Bailis et al., 2003). The country, however, lacks efficient governance and policies to counteract deforestation and enforce biomass

fuel management. While in some cases there are local regulations (e.g. for charcoal), there is no overarching national policy, which leads to ambiguity and inconsistent policies (Bailis et al., 2006).

The production of charcoal is especially inefficient and damaging to the environment. The pyrolysis process that is needed for the production of charcoal in eathern *kilns* often yields only 1 kg of charcoal from 6 kg of wood. Mainly urban households depend on charcoal for their energy needs: one household can be responsible for using between 1.5 to 3.5 tons of wood (Kebede et al., 2010). Since charcoal is also a commercial good it poses an even greater threat to the environment. A study by Mwampamba (2007) on Tanzania's charcoal production sector concludes it is "a real threat to the long-term persistence of forests in Tanzania" (p. 4221).

Reducing the demand for biomass fuels or a transition to cleaner (cooking) fuels could reduce the rate of Kenyan deforestation (Schlag and Zuzarte, 2008). A wide-scale adoption of ICS has the potential to contribute greatly. Furtermore, PSL can play a role in replacing the traditional open fire that is used for lighting.

2.3.5 Climate change mitigation

Greenhouse gasses (GHGs) such as CO_2, that are released when burning biomass fuels, have the capacity to trap radiated solar heat inside our planet's atmosphere. When the earth heats up this could lead to (regional) climatic change and have severe impacts on hydrologic cycles (Bala et al., 2010). Developing countries are largely affected since they do not have the means to adapt.

Today, we insert a lot more CO_2 into our atmosphere than is being taken out, leading to an excess that catalyzes climate change. It is estimated that around 730 million tons of biomass are burned on a yearly basis in developing countries: this amounts to more than 1 billion tons of CO_2 released in the atmosphere (World Bank, 2011). To compare, this is as much CO_2 as 215 average-sized coal fired power plants produce in a year (EPA, 2012).

Research done by Bailis et al. (2003) shows that charcoal contributes significantly more to climate change than woodfuel. While the combustion process of charcoal produces less CO_2 than the combustion process of woodfuel, more CH_4 and CO is produced. The latter two GHGs have a greater

Global Warming Potential (GWP)[5] than CO_2 (Bailis et al., 2003). Moreover, when considering the entire lifecycle of charcoal, the GHG's emitted during combustion appear only to be a fraction of the total. In the previous sub-chapter we learned how the charcoal production process is profoundly inefficient.

Kerosene lanterns also have a significant role in catalyzing climate change. Based on minimal performance criteria one lantern can reduce emission by 0.16 tons of CO_2. Worldwide, it is estimated the total amount of GHG's emitted from fuel-based lighting products adds up to 209 million tons of CO_2 equivalents (Mills and Jacobsen, 2011). Mahapatra et al. (2009) places this number at an estimated 112 million tons.

RET has the potential to reduce fuel use and therefore brings down GHG emissions. Some ICS, like the Envirofit G-3300, claim to bring down emissions by as much as 80%. More realistic studies estimate that the new generation of ICS has the potential to reduce CO_2 emissions by 25 to 50%, which still is a significant amount (World Bank, 2011).

2.4 Market barriers for the adoption of RET

While there have been some successes in RET dissemination, mainly in urban and peri-urban contexts, many programs have failed (Victor, 2011). We can acknowledge a number of barriers that potentially hamper large-scale distribution of ICS and PSL. The division of this sub-chapter was taken from an article by Schlag and Zuzarte (2008) (Figure 7).

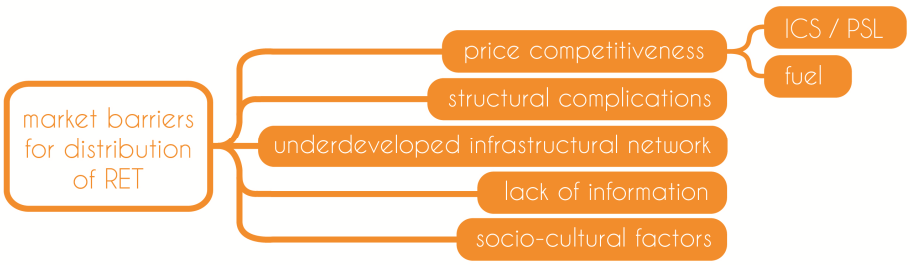

Figure 7: Market barriers for distribution of RET in rural Kenya (drawn up by the author)

[5] A measure to compare GHGs based on their potential to trap heat inside the earth's atmosphere

2.4.1 Price competitiveness of RET and associated fuels

In rural Kenya, where incomes are generally low, the price competitiveness of RET is one of the main determinants for wide-scale adoption (Schlag and Zuzarte, 2008). Since we aim to target the BOP this notion becomes even more pertinent. Clean fuels and stoves have to compete in price with the traditional stoves and fuels, which is a challenging objective. ICS and PSL comprise technologic designs and are constructed with high quality materials, which means production costs are considerable. Research and development costs also contribute to a higher retail price. Since, in most cases, production of RET occurs centrally, transport costs have to included (see sub-chapter 2.4.3). Additionally, the costs of market activation and marketing have to be taken into account (Bailis et al., 2009).

Before starting a distribution program it is important to assess what type of RET product should be distributed where. Since wood-based resources are not regulated, charcoal and woodfuels can be acquired at low costs. Schlag and Zuzarte (2008) found that in general in most SSA countries woodfuel offers the lowest monthly costs per household, while LPG is often the most expensive fuel choice[6]. In areas where wood-based fuels are commonly available the incentive to use a woodfuel stove is larger (Bailis et al., 2009). However, the relationship between fuel and stove use is not always clear-cut. Takama et al. (2011) found that especially lower incomes care more about the price of ICS than of its associated fuel. This, most likely, has to do with the fact that the capital costs form a barrier for adoption. For middle and high income groups the usage costs become more important, which implies these consumers might have a higher Willingness to Pay (WTP) for a product that performs better (e.g. more efficiently).

A fundamental issue that is relevant to discuss in this context is the fact that the poor in developing countries often do not have funds or savings available to spend on RET (Banarjee and Duflo, 2007). This partly has to do with the fact that keeping money inside the house brings the risk that it might be stolen. A more important rationalization however connects willingness to invest to education and lifestyle (Schlag and Zuzarte, 2008). BOP households - that live with less than US$ 2 per day - often live by the day, which means they do not consider direct needs they might have in the future. So, the

[6] The reader should take notice that fuel and stove prices differ per region and per context (e.g. rural or urban).

capital costs for investing in RET become a barrier to adoption. An additional complication is that the poor in SSA have very limited access to credit and saving initiatives (Banarjee and Duflo, 2007).

There are different ways of making RET more affordable to the target consumer. Financial arrangements with banks or SACCOs[7] can make RET more attractive. Allowing the customer to pay off his acquisition through an installment makes the product profoundly more accessible, especially to low-income groups.

Artificially lowering the price of the RET product that is to be distributed is another instrument we should discuss in this context. We can learn about the effectiveness of this strategy by looking at Senegal's highly successful butanization program that started in the 1970s. Because of increasing rates of forest degradation and deforestation authorities sought to introduce LPG[8] in order to replace the use of traditional biomass cooking fuels. By direct subsidies the government of Senegal influenced consumer fuel choice: today, over 85% of households of all income groups in Senegal make use of LPG. From 1988, demand for LPG grew steadily: by 15% annually. By slowly fading out the subsidy the sector is now regulated by the private sector (Prasad, 2008).

Another way of facilitating a reduction in retail price of RET involves obtaining financing through the Clean Development Mechanism (CDM). This Kyoto Protocol instrument aims to help developing countries lower their emissions and allows industrialized countries to invest in emission reductions is developing countries to meet a part of their emissions cap. However, García-Frapolli et al. (2010) poses that "entry costs of CDM are extremely high for small-scale projects, and the existing approved methodology that is applicable to cookstoves substantially underestimates carbon savings" (p. 2604). This implies that in many cases applying for a CDM arrangement does not make sense from a financial perspective.

[7] Savings And Credit Co-operative

[8] As mentioned earlier, LPG can be characterized as a modern, clean cooking fuel: it burns efficiently, without producing large amounts of harmful emissions.

2.4.2 Structural complications

When a large change in behavior is necessary it becomes increasingly difficult to promote adoption of RET among a wide audience. Related to this is the commonly heard complaint regarding the more advance ICS that it requires more and new skills to use (Victor, 2011). The Kenyan Ceramic Jiko (KCJ) - a charcoal stove - has been adopted by no less than 40% of urban Kenyan household since its introduction in the 1980's. The stove is very affordable at around US$ 4 and delivers considerate fuel savings compared to traditional cooking methods. According to Bailis et al. (2006) the key to the KCJ's success lies in the fact that urban households were already used to pay for both fuel and familiar with cooking on a stove. Adopting the KCJ required minimal change in behavior. In addition, local artisans helped to design the product in order to adjust it to the preferences of the local communities (Bailis et al., 2009).

Furthermore, it is important to provide the consumer with enough incentives to invest in RET. For households that rely exclusively on firewood, adopting ICS provides mainly non-monetary benefits, such as less health impacts and time savings. This is a barrier for adoption, since under these circumstances it is hard for people to see how their investment can be returned (e.g. through savings in medical bills, or possibility to increase working hours).

On a more practical note, the technological design of the product is a main determinant for the adoption of a RET (Quadir et al., 1995). The product needs to fit in the current lifestyle of the user. This means the demands for an ICS product might include preference regarding size, compatibility with cooking tools or certain shapes and sizes of pots and pans.

Lastly, Pode (2010) finds that when the product is of inferior quality it is a major barrier for adoption of RET. In the context of SSA, PSL and ICS might be used more intensively. This introduces the risk that the product can break. When this happens, the user might derive that "RET does not work". When this message spreads it can reduce WTP across a whole community.

Thus, in order to realize wide-scale adoption of RET, early adopters have to be increasingly satisfied with the product in question. This will catalyze word of mouth marketing. Anna Ingwe of GIZ (German Society for International Cooperation), an NGO that over 1.1 million ICS between January 2006 and December 2010, stresses the importance of after-sale services (personal communications, May 22, 2012). It is essential there is a *go-to* person available, that can provide information,

maintenance and reparations, when demanded. Naturally, this means skilled labor is required. Local actors are most suited for this function, since they are more accessible and appear more credible to the target consumer. Another key success factor for the distribution lies in involving local artisans in the design process, so as to make the product easy to use and compatible with the technical demands of Kenya's rural communities.

2.4.3 Underdeveloped infrastructural network

Especially in rural areas poor and underdeveloped infrastructure is a barrier for distribution in SSA (Schlag and Zuzarte, 2008). Rural households, in areas with low population densities, are hard to reach by distribution networks. Since RET in most cases concerns centrally produced products, transport is an important component in the supply chain. So far, most successful RET dissimilation initiatives, such as that of the KCJ, have focused on distribution in urban and peri-urban areas, where infrastructure is less of a problem and supply chains are smaller.

For distributors rural areas are often less attractive, since transport costs are higher, while there is less demand compared to urban areas. An article by Limão and Venables (2004) describes how the costs of trade go up because of factors such as remoteness, poor transport and communication networks. According to this same study poor infrastructure for a coastal country such as Kenya accounts for about 40% of estimated transport costs.

2.4.4 Lack of information

In rural areas people are often unaware of the existence of available RET and the associated benefits and potential future savings (Troncoso et al., 2011). The rural poor are regularly uneducated, or have had only basic education. To some extend this compromises their ability to judge how RET can contribute to their livelihoods and quality of live.

Information is an important factor related to the distribution of RET. In SSA, information flow between consumers, producers and intermediary parties is often poor. Kenya houses many different ethnic groups, has both densely and thinly populated areas and encompasses different geographic and climatic regions: all these variables affect cultural and sociologic parameters. There is often little detailed information per specific region available to determine whether commercially viable distribution of products is possible (Schlag and Zuzarte, 2008). Furthermore, rural households in Kenya have a very limited amount of means by which they receive information from outside their

communities or social circles (M. Maesya, personal communications, May 2012). While the adoption rates of mobile phones are increasing, many household are not connected to mass media channels, such as radio, television, let alone internet.

Market activation is an important activity for ICS and PSL distribution, since we presume the target population is not familiar with RET. Market research has to point out what the best way is to reach the consumer. Troncoso et al. (2011) suggests using hospitals and schools for raising awareness on the threats of traditional cooking and lighting.

As pointed out in chapter 2.4.2, local actors can play an extensive communicative role in relation to RET dissemination. In contrast to company representatives - that have no relation whatsoever to the target community - local actors are more accessible and approachable and thus can have a higher influence among peers (A. Ingwe, personal communications, May 22, 2012).

2.4.5 Socio-cultural issues

Kenya comprises 42 different tribes that all have different sets of beliefs and cultural backgrounds. A challenge to the widespread adoption of RET is the notion that these products have to replace products that are already embedded in these people's cultures. Social acceptability and limited participation of communities are barriers that have to be overcome (Pode, 2010).

What is exceedingly relevant to the successful adoption of RET is the compatibility of the product with the user's cultural preferences (Victor, 2011). In Kenya people have been cooking on three-stone open fires for centuries; not everyone will be open to modernization - even if they understand the benefits RET might bring. Open fires have an important social function, since they often are the only source of light in the dwelling at night. ICS are designed to minimize heat loss: this reduces their function as light source, as well as their space heating ability. These aspects make the adoption of ICS less attractive. Ruiz-Mercado et al. (2010) speak about the performance of stoves related to specific tasks and meals that have to be cooked. Depending on the stove, the performance might differ per task. Additionally, individuals might have different preferences regarding taste and cooking process that might influence their stove choice. Again, the role here for local artisans could be an important one.

Another socio-cultural issue relevant in this context is related do with patriarchy and the fact that the head of the household, who is in charge of most financial decisions, is often male. While it is the women who do the cooking, the men decide whether or not to spend money on an new stove. This leads to ineffective decision-making: men are often not familiar with the standards the product has to comply with (Schlag and Zuzarte, 2008). Furthermore, it is found that in general women are more responsible when it comes down to making household decisions or decisions that might benefit the welfare of children. Compared to women, men spend a larger amount of their budget on luxury goods, such as alcohol and tobacco (Sequino, 2010).

Finally, it is important to understand how people valuate different assets in another culture. In Maasai communities livestock represent status: the more livestock one owns the wealthier he or she is (Bailey, 1999). This perception might stand in the way of an individual's willingness to invest in RET in these areas. We will further go into the value of livestock in chapter 2.5.3.

2.5 Livestock and livestock markets

It was hypothesized that livestock markets are suitable places to start distribution of RET to Kenya's BOP. This study aims to assess to what extent this is true. Based on the result of field work research we study whether the determined market barriers can be overcome. This sub-section sets out by elaborating on the initial rationale for selecting livestock markets as potential distribution points.

2.5.1 Rationale behind distribution concept

In rural Kenya livestock is an important asset, especially in Maasai regions where our research takes place. Homewood et al. (2009) found that between 92% and 95% of all Maasai households own livestock; this means they are therefore in some way, directly or indirectly, connected to livestock markets.

Depending on the type, these livestock markets can attract large amounts of visitors, which implies that their might also be considerable amounts of money circulating. Selling an animal will bring in a large sum of money to the trader that could potentially enable him to purchase a RET product – this realization is closely linked to the main research question. Moreover, this feature makes the livestock market stand out, and more suitable in this context compared to other types of markets. Another

attribute of livestock markets is that they attract visitors from a wide radius, which would mean households from remote locations could be reached through livestock markets (J. Kitala, personal communications, May 2012).

2.5.2 Types of livestock markets

It is possible to distinguish between three types of livestock markets in Kenya: primary, secondary and terminal markets (Mahmoud, 2011). These livestock markets differ from each other in organization and characteristics (A. Abdi, M. Maesya, personal communications, May 2012).

Primary markets attract mostly rural livestock producers (Figure 8). These markets are located inland; mostly in more remote areas. They are limited in size and mainly visited by small-scale livestock owners. Traders visit primary markets to purchase livestock in bulk so that they can resell the animals in secondary markets.

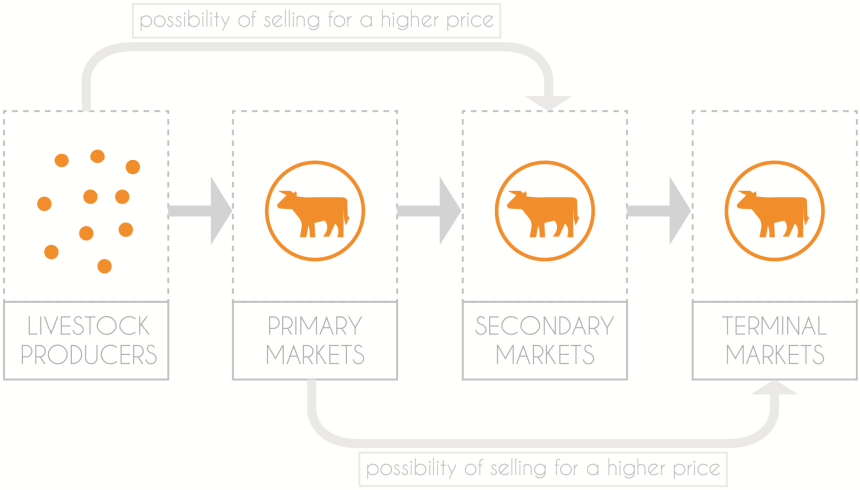

Figure 8: Scheme of livestock market hierarchy (drawn up by the author)

Secondary markets attract a more diverse audience. They are bigger than primary markets and generally better accessible. Considerable amounts of liquid money circulate these livestock markets. Since prices generally lie higher it makes sense for traders to sell livestock bought from primary markets; it also makes sense for livestock owners to travel longer distances to visit these types of markets.

Lastly, terminal markets focus on the end product of livestock (e.g. meat, pelts) and are located in close proximity to cities, where the demand for these products is high (Mahmoud, 2011). This means terminal markets are visited primarily by butchers and urban dwellers. Generally the prices paid for livestock in these markets are even higher than in secondary markets.

When in need for money, each livestock owner naturally would like to sell his animals for the highest price possible. However, it is it is dependent on the mobility and welfare of the livestock owner what his options are (A. Abdi, J. Kitala, M. Maesya, personal communications, May 2012). Livestock producers often have low incomes and are limited to travel by foot. This means they are often not able to visit secondary or terminal markets, where they would receive more money for selling his or her animals. On the other hand, the more wealthy traders, that can afford to buy livestock in bulk from primary markets make use of trailers when transporting animals.

A recent development in which SNV is involved together with the Kenyan Ministry of Livestock (KML) is a market information system, that allows livestock owners to access market information either through SMS or through Internet. Free of charge, and without having to travel, the livestock owner can now find out about the market dynamics and prices for which animals are sold in a specific market[9]. This development makes the markets more accessible for livestock owners and helps to regulate the prices.

2.5.3 The value of livestock

In pastoralist Kenya livestock is an important asset. The animals provide a way to store wealth and function as insurance in case money is (instantly) needed (Bailey et al., 1999). Moreover, the animals provide a range of useful goods such as milk, meat, pelts, blood and manure that contribute to people's livelihoods.

To the Maasai, livestock represents status and welfare. This notion is illustrated by the Maasai proverb "you don't sell a cow to buy a shoe", which basically prescribes that one does not sell an animal for one particular need (M. Maesya, personal communications, May 2012). In general, Maasai households will hold on to their livestock until a complete shopping list is compiled (e.g. shoes, food,

[9] see: http://www.lmiske.net

clothes, etc.). Then, the right animal is selected for selling, so that that the money yielded can pay for the required goods. Exceptions to this mentality include selling livestock for paying medical bills and school fees (A. Abdi, M. Maesya, M., personal communications, May 2012). In fact, the livestock market becomes more active in periods wherein school fees have to be paid: many households need to sell livestock, more or less at the same time, in order to acquire the financial means.

The cultural importance of livestock can be derived from social constructions such as marriage and inheritance. When marrying, considerable amounts of animals have to be paid to the family of the bride as dowry: in fact it is the largest payment most Maasai men will ever make in their life (Bailey et al., 1999).

It is relevant to understand the value of livestock in relation to this research, because we want to understand our sample population. When having to decide between selling livestock or investing in RET Kenyan pastoralists might have a preference for the former. To them, RET is not considered to be a valuable asset. One might argue that this is another reason why the livestock market might be suitable as a point of sale: here, the livestock owner has already sold an animal, which means he or she now has money available for purchasing RET.

2.6 Synthesis

According to the literature, energy is an essential factor for socio-economic development. Lack of access to modern energy services can be connected to a variety of poverty indicators, such as illiteracy, life expectancy and child mortality.

In Kenya, and most Sub-Saharan African countries, the vast majority of all households rely on biomass fuels for cooking. Traditional cooking setups, like cooking over a three-stone open fire, are inefficient for burning biomass fuels and lead to indoor air pollution, which is one of the main causes of death in SSA. Moreover, biomass consumption can result in severe forms of deforestation and degradation of woodland resources. Especially, the production of charcoal is damaging to the environment. Besides impacts on forest covers, climate change is another environmental impact caused by biomass fuel combustion.

While households in Kenya use little energy by comparison, they spend a disproportionate share of their budget on it. Kerosene, on which the majority of households in Kenya rely for lighting, is a major expense among the rural poor. An additional nuisance related to using kerosene lanterns is the fact that the light they produce is of poor quality.

Renewable Energy Technology can provide the solution and help alleviate energy poverty among the BOP in SSA. Especially in rural areas, where electrification rates are low, Improved Cookstoves and Photovoltaic Solar Lanterns provide a range of benefits that help improve livelihoods and reduce health impacts of rural households. In order to successfully distribute RET, however, a range of market barriers have to be overcome.

Raising awareness concerning the threats of traditional cooking and lighting is a crucial aspect before starting distribution. Through further research the right channels for communication have to be determined. Local actors need to have a prominent role in this, since they can enhance the acceptability of the program and are more approachable for local households.

Price competitiveness of RET is another key factor for wide-scale adoption in rural Kenya. Clean fuels and stoves have to compete in price with the traditional stoves and fuels, which is a challenging objective. This is partly related to the notion that infrastructure in SSA is generally poor, which makes transport more difficult and expensive. There are however different ways of making RET more attractive to the target consumer: for example, allowing the customer to pay off his acquisition through an installment.

Furthermore, when a large change in behavior is necessary it will become increasingly difficult to promote the adoption of RET among a wide audience. We can relate this market barrier to socio-cultural factors or structural complications. A key success factor for distribution that we can derive from preceding dissemination programs prescribes selling a product that is compatible with the cultural demands and technical preferences of the consumer.

It was hypothesized that livestock markets are efficient places to start distribution of RET to the rural poor. In pastoralist Kenya livestock is an important asset: the animals provide a way to store wealth and produce commodities that contribute to people's livelihoods. Most households in rural Kenya own livestock and therefore have a connection to the livestock market. Depending on the type, livestock markets can attract large amounts of visitors. We can distinguish between primary, secondary and terminal livestock markets. Each of these markets is different in structure and attracts a different audience.

3. Methodology

3.1 Study area

It was decided to select two locations for research to study whether livestock markets might be suitable places for commercially viable dissemination of RET. Comparing the results between two livestock markets could potentially give insight into consumer profiles and behavior across a wider population. Moreover, it will allow for a comparison analysis between the two sites.

Secondary markets were found to be most suitable for the distribution of RET. Secondary livestock markets are located in rural areas, but are generally better accessible for distribution networks than primary markets. In addition, in contrast to primary markets, visitors of secondary markets often travel larger distances to get there, which implies a wider audience can be reached. Terminal markets on the other hand are less suitable in this context than secondary markets. These markets attract less rural visitors and more middle and high income traders from urban areas, which is not the target group for this study.

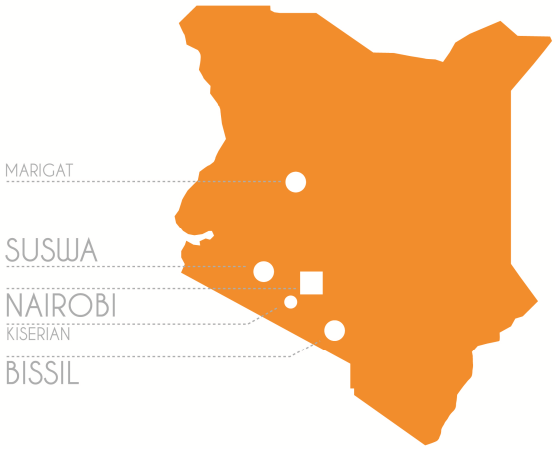

Figure 9: Map of Kenya with selection of locations relevant to this study (drawn up by the author)

Two livestock markets were selected as study areas: the market of Bissil in the county of Kajiado and the market of Suswa in the county of Narok (Figure 9). Both sites comprise secondary livestock markets that are similar in organization and size. The markets are located in semi-arid areas. Moreover, both markets are relatively easily accessible when traveling from Nairobi, where SNV is based. This was beneficial in terms of logistics and, indirectly, finances. Another aspect that was considered was the fact that both regions, while geographically separated, house Maasai

communities. This means the ethnicity of the visitors of the livestock markets can be included as a constant. Lastly, in Suswa and Bissil, the market dynamics were comparable: the market starts in the morning and begins to clear out by mid-afternoon.

3.2 Research methods

Based on the scope of this research, the scale and the findings from the literature review the research methods for this study were selected (Figure 10). The main focus will be on quantitative data collection through a structured questionnaire. A substantial section of this questionnaire is dedicated to economic valuation by means of the Contingent Valuation Method (CVM). Qualitative research was done by conduct key informant interviews. Lastly, observation studies were done in three locations in order to be able to thoroughly explore the context of this research.

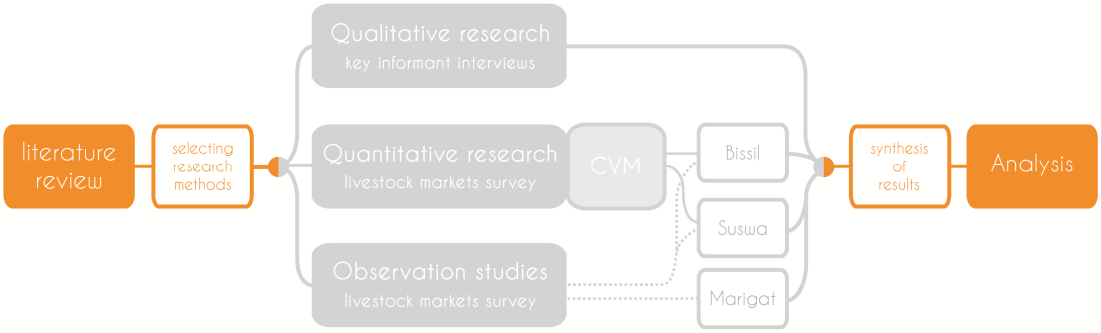

Figure 10: Setup of research (drawn up by the author)

3.2.1 Structured quantitative data collection

The main focus in this study is structured quantitative data collection. This research approach seemed most appropriate for gathering information on the target consumer and to test the potential of livestock markets as points of sale for RET. A questionnaire was developed for collecting data on socio-economic characteristics, energy situation, awareness regarding RET, and Willingness To Pay (WTP) for RET by employing CVM. By means of statistical analysis this thesis aspires to develop a critical assessment of demand for ICS and PSL technology in Kenya's pastoral areas.

Sample frame / survey implementation / pre-testing

The survey was implemented through personal interviews on the livestock market itself. A team of three enumerators was assembled for this task, with members that were capable of speaking the

local tribal language, Maasai. They were trained and supervised during interviewing by the author. The target sample group comprised traders (buyers, sellers) and visitors of both the Bissil and Suswa livestock markets, male and female, from the ages 18 and over. The interviewers were told to randomly select participants.

When commencing the interview, the enumerators were instructed to first introduce themselves, and then the topic and relevance of the research. Moreover, the enumerators were trained to conduct the questionnaire in an interactive and conversation-like manner, so as to avoid respondents losing interest or concentration. Overall, most people that were approached were willing to participate.

For pre-testing, the livestock market of Kiserian was visited (Figure 9). Kiserian is actually a terminal market, but was selected for logistic reasons. After pre-testing, the questionnaire was modified and optimized before visiting Bissil and Suswa. The goal agreed to with SNV was to complete at least 40 questionnaires per market. On forehand was decided to pay two visits to each location with the option to visit a third time, should this be necessary.

Questionnaire design

The questionnaire consists of six main sections and was designed to take between 20 and 30 minutes (appendix B). The first section involved basic questions on sociologic characteristics of the respondent and aimed to familiarize him or her with the interviewing process and the interviewer. Part 2 dealt with the relationship of the respondent and the livestock market, while part 3 consisted of questions on assets and decision making. Part 4 comprised enquiries on energy use and lighting and cooking equipment. Part 5 revolved around measuring the respondent's awareness concerning RET and CVM, on which the next sub-chapter shall elaborate. Finally, the last section included questions on income, savings and loans.

When appropriating the use of a survey there is always the possibility of biases occurring. In order to maximize the quality of the research it is sensible to try and anticipate these biases on forehand, so as to limit their presence or impact. By asking control questions the quality of given responses can be evaluated.

As with any questionnaire the question arises: do respondents answer truthfully? Some questions might involve sensitive topics; this may cause the respondent to give an answer that might differ from his own opinion. As a rule it makes sense to place questions that relate to possible sensitive issues (e.g. income) at the end of the questionnaire. This avoids the risk of respondents refusing to participate further somewhere in the questionnaire - this is known the *partial-response bias* (Abdullah and Jeanty, 2011). Other reasons why a respondent's answer might differ from his actual opinion could be because he or she wants to seem knowledgeable, wealthy or compliant. We refer to this effect as *response bias*. By stressing the survey is anonymous and applied on a wide scale, it was attempted to minimize these effect.

Information bias can occur when there is an error in the design of the questionnaire, from which an individual can derive a meaning or notion that can influence his or her answer. By constructing the questionnaire in a structured manner and having it assessed by different supervisors the chance of this bias occurring was diminished.

3.2.2 Contingent Valuation Method

Willingness To Pay

Contingent Valuation Method (CVM) is a direct way of measuring whether people are willing to pay for a product or service by using a structured questionnaire. The method, derived from economic theory (consumer theory), is frequently used in environmental economics to study whether respondents are willing to pay for the benefits of an environmental intervention (Fujita et al., 2005).

Willingness to Pay (WTP) tests an individual's personal interest in a specific good or service and is measured in currency - Kenyan Shilling in this context. Thus, WTP measures only the demand side of the market. When applying CVM it is essential to give a clear briefing of the service or good in question, before asking for the respondent what would be the *maximum* price he would be willing and *able* to pay for it (Whittington, 1998). This means that in our study, the benefits of RET and the dangers of traditional cooking and lighting were explained to the respondent. Ideally the measured WTP is equal to the respondents actual WTP: for this reason it is important to instruct the respondent to consider the budget that is available to him or her.

A payment card can be used to aid the interviewee in deciding upon a specific sum: it strategically lists a range of possible amounts that can serve as example. The next sub-chapter will elaborate on the design of this tool.

Specifically in relation to CVM we should anticipate the occurrence of certain biases. One of these is known as *hypothetical bias*: the WTP given by a respondent can deviate from his or her actual WTP, since he or she does not *really* have to pay anything (Abdullah and Jeanty, 2011). To minimize this bias, the interviewers where instructed to stress the fact that the household's budget had to be taken into account. Moreover, after getting a response, the interviewer would ask the respondent to confirm the answer given truly represents his or her maximum WTP.

Another bias that is known to occur in CVM studies is known as *starting point bias*. This bias implies that the value indicated by the respondent as WTP is influenced by the value at which the payment card starts. By designing the payment card according to Rowe's methodology a wide range of rationally determined values was generated, so as to diminish the occurrence and / or impacts of this bias (see next sub-section).

Payment card design

The payment cards adopted in the questionnaire were designed according to a theory set out by Rowe (1996) (Appendix B). For each product a new payment card was generated to offer an appropriate set of values.

Rowe's theory is based on two pillars. Firstly, he poses that "the accuracy with which respondents can estimate values is proportional to the value" (p. 179). This means that the higher the WTP the respondent indicates, the higher the level of inaccuracy we should appoint to the claim. Therefore it would make sense to adopt an exponential scale. Secondly, Rowe refers to Weber's law that describes the relationship between 'just-noticable' difference between two stimuli (e.g. light sources), as can be perceived by humans. Psychologists have discovered there is a pattern when asking respondents to distinguish between a sequence of stimuli that differ slightly from each other with increasing intensity. Rowe offers that since this law follows an exponential scale it can also be used to generate a payment card design. This design should follow the following formula:

$$B_n = B_1 \times (1 + k)^{n - 1} \qquad (1)$$

Where *k* is a positive constant with a value selected so that $(1 + k)^{n - 1}$ equals the payment cards highest value. The size of the sequence is represented by the variable n; B_n then is a specific value in the sequence. The value of the first cell is US$ 0. The values of the cells 2 until cell *n - 2* can then be calculated. Finally, the table should include one cell that presents the option 'value > n' and 'i don't know'.

Renewable Energy Technology proxy products

In order to employ CVM to get an insight whether commercially viable distribution of RET is possible, it was necessary to needed to select two proxy products - both an ICS and a PSL product. These products should be representative for their type and were taken from the catalogue of products React Africa aims to distribute.

The first product that was selected is the Envirofit G-3300 firewood stove (Figure 11). The stove is designed in the United States and manufactured in China. The retail price is around KSh 3,500[10] and comes with a 5 year warranty. The producer claims the stove delivers up to 60% fuel reductions, 40% reductions on cooking time and reduced harmful emissions by 80% (Envirofit, 2012). However, according to field testing by Adkins et al. (2010) these claims are overly optimistic: their findings report fuel savings up to around 40%, depending on the meal that was cooked. This same study found that the Envirofit has a 16% increased cooking time on average compared to a three-stone fire.

Figure 11: Envirofit G-3300 stove (source: envirofit.com)

[10] Corresponding to US$ 41.69 at the time of writing

The D.light S10 lantern is the least expensive of the Photovoltaic Solar Lanterns React Africa means to distribute: it goes for around KSh 1,450[11] (Figure 12). However, it was decided to include the more advanced Trony Solar Sundial TSL-01 in the survey, since it has the option to charge mobile phones.[12] This lantern has a retail price of around KSh 3,400[13]. The manufacturer's warranty is 2 years. The independent program Lighting Africa[14] (LA) tests the performance of PSL. According to LA the Trony Solar Sundial TSL-01 can give up to 13 hours of light in the low brightness setting. The light output has a maximum of 78 lumens.

Figure 12: Trony Solar Sundial TSL-01 lantern (source: trony.com)

3.2.3 Observational studies

In order to assess the availability of energy products and the commercial viability of RET it was necessary to also complete observational studies on the livestock market and in the town itself. This was done in both the Bissil and Suswa location. Moreover, to explore one additional livestock market outside of Maasai regions it was decided to also visit the market in Marigat, in the county of Baringo, 5 hours to the northwest of Nairobi. The livestock market of Marigat can also be characterized as a secondary market. However, it is subject to different visitors, climate and general influences compared to the other sites. Studying this market should give additional insights as to livestock markets function across Kenya.

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11 Corresponding to US$ 17.27 at the time of writing

12 During pre-testing it was found that some respondents assumed this option was available in all PSL. Moreover, respondents generally seemed to value this option highly.

13 Corresponding to US$ 40.50 at the time of writing

14 LA is a joint initiative of the World Bank and the IFC

3.3 Analysis

3.3.1 Statistical analysis

The data collected from the survey was analyzed using SPSS software. All data derived from the survey was entered into a database from which SPSS enables the user to run statistical tests. In this study statistical analysis was used to determine the factors that contributed to a respondents WTP. Mainly, three types of tests were used: t-test, chi-square test and regression analysis. The next sub-chapter will deal more extensively with regression analysis.

The independent t-test can be used when comparing two samples. Both in normal and non-normal distribution the t-test is an instrument to determine whether the means of two samples differ from what is expected (Dekking et al., 2005). In order to be able to complete a t-test it is essential to construct a hypothesis (H_0) beforehand. The t-test than can be used as a tool to explain whether the findings correspond with what was anticipated. Based on what is found the H_0 hypothesis can either be accepted or rejected.

While the t-test works with continuous numeric data, Pearson's chi-square test can be applied to run analyses on categorical data (e.g. income categories). The test sets out two variables against each other and compares the frequencies of outcomes to the frequencies that are to be expected (Fields, 2005).

3.3.2 Regression

In regression analysis we construct a predictive model to match with our data. In a linear regression the model assumes a linear relation between a dependent (DV) and a series of independent variables (IV) (Fields, 2005). Our regression model has the following format:

$$Y = \hat{\alpha} + \sum_{i=1}^{n} \hat{\beta}_i x_i + \varepsilon_i \qquad (2)$$

In this model Y represents the dependent variable. In this study we will look into Willingness to Pay for PSL and ICS. Then, $\hat{\alpha}$ represents a constant: the part of the model that is not predictable. The independent variables x_i are each connected to their own coefficients $\widehat{\beta\iota}$.Lastly, ε_i is the residual term that represents the difference between the predicted score and the actual outcome. Conclusively, the aim is to find the combination of predictors that correlates optimally with the outcome variable.

One has to be careful not to include too many independent variables in regression analysis. Field (2005) poses we can use 15 cases of data per predictor. Of course, in order to deliver strong statistical data a larger sample size will always be better, but since in this study we are dealing with a relatively small sample size of 108 cases it seems reasonable to aim for around 7 predictors.

In order to assess the robustness of our regression model it is important to consider the R^2 value. R^2 gives us the amount of variance in the outcome that can be explained by the model. It basically tells us how much of the model can be explained through our IVs and thus can give an estimate on how well the model fits with the obtained data and presents an indication of the strength of the relationship (Field, 2005). Since this study is modest in size we have to take into account the statistical value of the models presented in this dissertation is limited.

3.4 Limitations in field work research

A number of limitations have to be taking into account regarding the methodology of this research. Due to time constraints it was only possible for the author to visit Kenya for two months. This, to a large extent, defined the scale of this research. In order to narrow down the focus of the research it was decided to study the demand side of the market: the potential buyer of RET.

In Kenya, the time available for data collection was short. The livestock markets that were selected for field work are not held every day. The Bissil market is held twice a week; the Suswa market once a week. Moreover, the markets are mainly active in the morning. By keeping to a schedule set out early on in the research process it was possible to efficiently carry out the survey.

SNV provided three assistants to assist in taking questionnaires with the local communities. These assistants were familiar with the local tribal languages. Most respondents in the Bissil and Suswa locations were unilingual and spoke Maasai. This meant the enumerators had to translate the questions into this language, which implies their role as interpreters could have had impact on the responses. To ensure the quality of the questionnaire the enumerators where supervised during their first three to five interviews.

In total 118 surveys were completed, including the pre-test. The target sample group per market is only a small selection of the total sample population. Naturally this increases the risk that the sample does not adequately represents the sample population. Moreover, a limited amount of cases also limits the strength of statistical analysis. The size of the sample group is directly related to the robustness of the analysis.

4. Results and Discussion

4.1 Socio-economic characteristics

4.1.1 Demographic characteristics

Table 1 presents the demographic results from the survey across the two locations and accumulated in the far right column. In both locations the male/female distribution (70% male in Bissil; 67.2% in Suswa) and the age distribution of respondents (a mean of 36.9 in Bissil; mean of 37.4 in Suswa) are comparable. Also, in both locations, almost all respondents were Maasai: 98.0% in Bissil compared to 93.1% in Suswa. Most respondents indicated their main occupation involved tending to livestock. Conclusively, these results seem to suggest both samples are comparable to each other when we consider sociologic characteristics.

	Bissil		**Suswa**		**Total**	
	n	**descriptive**	**n**	**descriptive**	**n**	**descriptive**
Sex (% male)	50	70.00%	58	67.20%	108	67.3%
Age (years) [M/SD]	48	36.96 (12.14)	58	37.38 (11.33)	106	37.07 (11.65)
Household size [M/SD]	50	8.50 (8.60)	53	10.98 (8.965)	103	16.09 (37.71)
No. of children (<18)[M/SD]	50	3.60 (3.33)	58	5.86 (5.40)	108	4.81 (4.70)
Literate (% yes)	49	49.0%	58	39.7%	107	43.9%
Occupation (%)	50		58		108	
Farming		10.00%		13.80%		12.0%
Livestock		64.00%		77.60%		71.3%
Dairy		4.00%		3.40%		1.9%
Trading		2.00%		1.70%		8.3%
Salaried Employment		4.00%		0%		1.9%
Casual Labor		4.00%		0%		1.9%
Student		0.0%		1.70%		0.9%
Artisan		0.0%		1.70%		1.90%

Table 1: Demographics

In Kenya education rates are high compared to other SSA countries, with a literacy rate of 85.1% (CIA Factbook, 2012). The rural population seems somewhat less educated: of the respondents in Bissil 49.0% went to primary school; in Suswa only 39.7% did (Figure 13). This difference was not found to be statistically significant (Appendix C). In both locations, none of the participants of the survey had completed a university education.

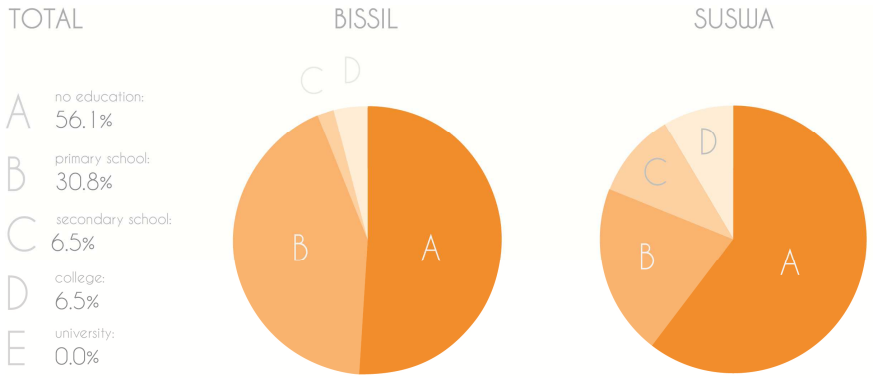

Figure 13: Education rates between two locations

Further analysis of the collected data by means of t-testing confirms our H_0 hypothesis that men are generally better educated that women (appendix D); literacy rates were also higher among men. This finding corresponds with the H_0 hypothesis and could be related, at least partly, to patriarchy and the fact that women have to look after the children and take care of household tasks, leaving them little time for studying.

Household size in Bissil and Suswa was on average 8.50 and 10.98 people respectively. Households in Suswa seem to have significantly more children, about 2.26 more according to this study (Appendix C).

Discussion

Thus, we found that education rates are low in both study areas. Through literature review it was found that lack of information is a barrier to distribution of RET. We can expect that people who have had little education or are illiterate are less informed of the negative effects of traditional cooking and lighting methods. This implies they might not see the benefits of adopting ICS or PSL. Educating the target population on the benefits of RET is exceedingly important. Further research will have to point out what the most efficient communication channels are. Possible options are targeting the consumer through radio, road shows or text message. Specific efforts will have to be made as to overcome patriarchal issues (e.g. in order to be willing to adopt, men have to understand that ICS not only benefits women).

As to be expected in rural Kenya, household size can be substantial. A larger amount of children in a household could mean a higher incentive to adopt RET. After all, adopting RET could result in a reduction in monetary spendings, reduce health impacts or increase time available per household member to work or study. In sub-chapter 4.4 we will look into how these factors could influence WTP for RET.

4.1.2 Income and savings

Looking at the table below we see that in total 39.0% of the respondents has an income of KSh 5,000 or less. Considering that KSh 5,000 a month translates into US$ 59.56 this means that these households have to live off less than US$ 2 a day. In Bissil the people are significantly less wealthy than in Suswa; almost 54.5% of the respondents have to live of US$ 2 a day (appendix C). What should be added to this is that households in both sites do have considerable amounts of livestock, which contribute to their livelihoods - we will go into this in the next sub-chapter.

	Bissil		**Suswa**		**Total**	
	n	**descriptive**	**n**	**descriptive**	**n**	**descriptive**
Income (%)	44		56		100	
KSh < 2,000		22.70%		8.90%		15.0%
KSh 2,001 - 5,000		31.80%		17.90%		24.0%
KSh 5,001 - 10,000		25.00%		28.60%		27.0%
KSh 10,001 - 15,000		4.50%		19.60%		13.0%
KSh 15,001 - 25,000		6.80%		5.40%		6.0%
KSh 25,001 - 35,000		4.50%		1.80%		3.0%
KSh 35,001 - 45,000		2.30%		5.40%		4.0%
KSh > 45,001		2.30%		12.50%		8.0%
Savings (% yes)	46	30.40%	56	42.90%	102	37.3%
Amount (KSh) [M/SD]		31.308 (57.431)		86.317 (152.135)		67.457 (129.403)
Loan (% yes)	45	22.20%	56	25.00%	101	23.8%
Amount (KSh) [M/SD]		204.375 (196.058)		143.400 (154.876)		170.500 (171.751)

Table 2: Economic characteristics

The survey found that in total 37.2% of the respondents had savings. This is more than one might expect after reading *"The economic lives of the poor"* by Banerjee and Duflo (2007). A possible explanation for this might be related to the mobile banking system M-PESA, that was introduced by telecom provider Safaricom in Kenya in 2007 (Morawczynski and Miscione, 2008). M-PESA allows the user to check his or her account balance, store funds, make transactions, withdrawals and pay bills through their mobile phone. Since 2007, M-PESA has attracted over 5 million users and a network of over 5,000 agents. M-PESA has already been labeled a 'transformational' invention that provides a

financial solution to the 'unbanked' Kenyan population (Morawczynski, 2009). The average amount saved over the two locations is KSh 67.457[15].

Many respondents indicated using M-PESA to save money, to buy cell phone credit and to pay bills with. In this context it should be noted that M-PESA could potentially be used to pay for RET. More M-PESA related financial constructions have emerged, such as M-KESHA which allows the user to save money. Other applications enable the user to pay school fees through mobile banking.

22.2% of respondents indicated to have ever had a loan in their lives, with purposes ranging from funds needed to invest in livestock, to build a house or to buy land. Different banks such as Equity Bank and K-rep provided the loans, as well as the Kenya Woman Finance Trust (KWFT). The KWFT is a microfinance organization that helps women set up businesses.

Discussion

From the responses given by participants of the survey and looking only at income we can conclude that a large share of the sample population is part of the *rural poor.* In the next sub-chapter we will reassess the welfare of the sample population based on their assets and livestock ownership. So far we can summarize that incomes are low and the majority of households does not save. Getting a loan is often difficult or impossible. This means households may not have the means to invest in RET.

We can relate the income level of households in the study area to price competitiveness of RET, which was recognized as a major barrier for wide scale adoption. Based on the financial situation as indicated by the respondents of the survey, the ICS and PSL products React Africa aims to distribute seem to be overly expensive[16]. Considering that 66.0% of all respondents stated a household income less than KSh 10,000 a month the retail price of these products comprises over a third of their monthly budget. So, based on the data collected on household finances, one could argue that perhaps the RET products selected for sale by React Africa are overly expensive for the BOP.

[15] Amounts to US$ 711.30 at the time of writing

[16] See sub-chapter 3.2.2: retail prices Envirofit G-3300 stove and Trony Solar Sundial TS-01 are KSh 3,500 and KSh 3,400 respectively

A suggestion as to how to overcome this market barrier would be to look into collaboration with banks or SACCO's. By enabling the target consumer to purchase RET through an installment it might become more attractive to invest.

4.1.3 Assets and livestock

From Figure 14 we can learn that almost all people in the study areas own mobile phones and radio's; this also includes the poorest households. The phones are sold and can be charged in a range of shops in both Suswa and Bissil town. In case of Suswa the livestock market is already used as *point of sale* for mobile phones. Private *Matatus*[17] arrive from Nairobi with young women selling these products.

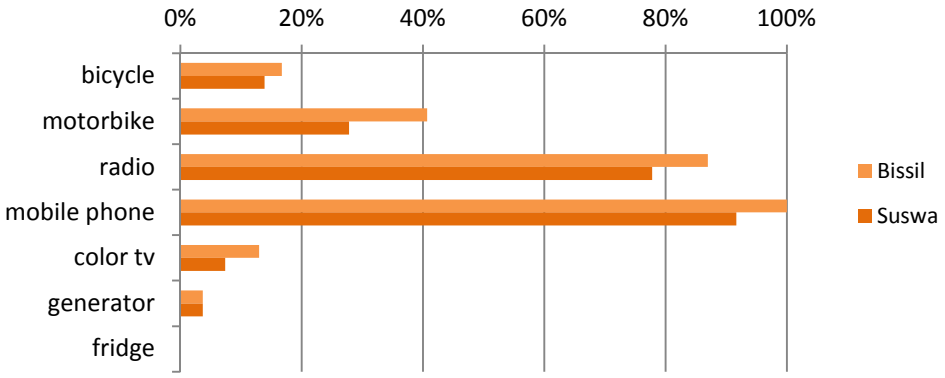

Figure 14: Assets owned in both study areas

Even though it was not found to be a significant disparity by t-test analysis, it is remarkable that in Bissil households, on a percentage basis, seem to own more technological assets - or at least the same amount when we also consider generators and fridges. Earlier we found that incomes are lower in Bissil, so it is difficult to connect an explanation to this finding. Perhaps in Suswa people have less interest in technological products, which could explain why they have less radios, mobile phones and televisions. Furthermore, it could be argued that visitors of the Suswa market travel less and shorter distances to visit the livestock market, so they might have less need for bicycles and motorbikes.

[17] Small van

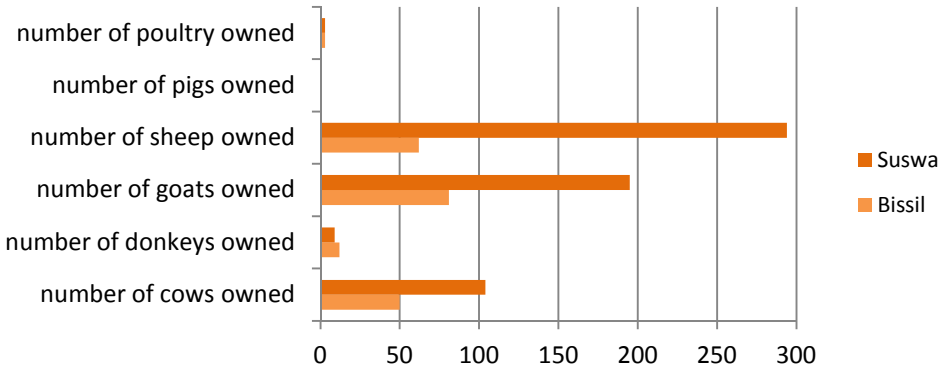

Figure 15: Average amount of livestock owned in both locations

What can be concluded from the graph above and further independent t-tests is that households in Suswa own significantly more livestock than households in Bissil (appendix C). This fits with our H_0 hypothesis: incomes in Suswa were also found to be higher (chapter 4.1.2). Respondents from Suswa stated to on own on average around 4.5 times the amount of sheep; around twice the amount of goats and cows. Pigs, donkeys and poultry were not traded in the livestock markets included in this study. While we have to consider the occurrence of response bias, the difference between the two locations is substantial.

Discussion

This study shows that, apart from radio and mobile phones, households generally do not posses other technological products. Based on these results it is likely that households in these areas have little affinity with technology. It appears that, in general, Maasai do not seem open to modernization. Today, cultural traditions and values still play an important role in their lives. Observation studies and interviews with local actors indicated that Maasai have little need for materialistic assets, apart from livestock. This is a clear market barrier for the distribution of RET.

That almost all households own radio's is an interesting finding, since this is the only mass broadcasting medium that can be used to reach these households. From an entrepreneurial perspective it would make sense to look into using radio for market activation or educational purposes.

From the results presented in the previous sub-chapter we can learn that incomes are generally low in the study areas. However, we have now seen that households in these areas own considerable amounts of livestock. Livestock has, of course, a monetary value, but also provides goods (e.g. milk, meat) and services (e.g. transport) that contribute to the livelihoods of pastoralist households.

Based on livestock ownership it appears that the majority of respondents is not part of the BOP. The average price paid for a cow in Kenya, measured on June 5, 2012, was KSh 25,100, for a goat KSh 3,530 and for a sheep KSh 3,045[18] (LMISKE, 2012). Based on the questionnaire responses, in Bissil, where people were poorest, households on average own 50.46 cows. When calculating the monetary value of this amount of livestock we find a total of US$ 15,099.48. It seems impossible to connect this amount of money to Kenya's rural poor. However, what complicates this assumption is that the value of livestock, as discussed in chapter 2.5.3, cannot be captured only in monetary terms. Livestock represents status and is not sold unless it is perceived absolutely necessary by the owner. In dry years large-scale starvation among livestock is not unusual: their owners hold on to their animals too long, until the market collapses and selling is no longer an option (J. Kitala, personal communications, April 16, 2012).

4.2 The relation between the livestock market and the consumer

In order to start RET dissemination from livestock markets it is important to understand how these markets operate. An important feature related to constructing a distribution strategy is the fact that livestock markets are similarly organized throughout Kenya (J. Kitala, personal communications, April 16, 2012). Observations studies in Bissil, Suswa and Marigat confirm this. In general there is a clear relation between the livestock market and the town's commodity market. This can also be interpreted from Figure 16: nearly all respondents buy clothes, food and other goods when visiting the livestock market.

[18] US$ 298.09; US$ 41.92; US$ 36.03 respectively

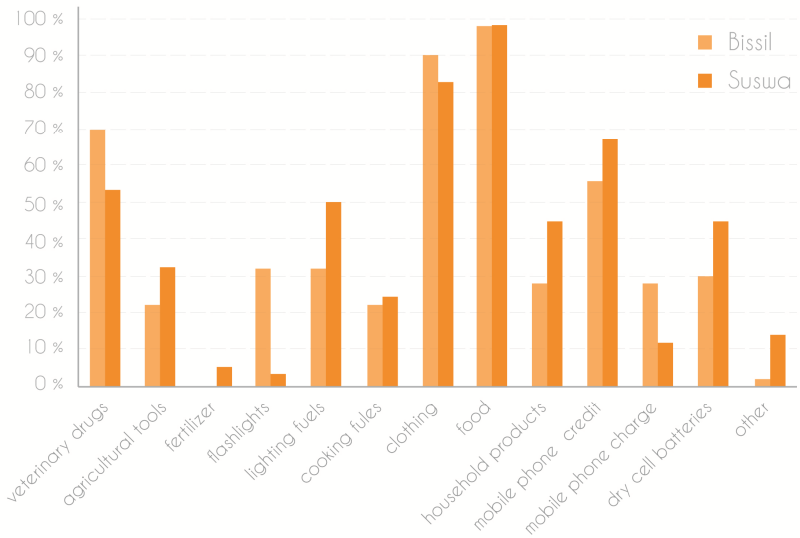

Figure 16: Products bought by respondent, per location

Between the two markets financial flows occur (Figure 17): what can be seen happening is that, for example, a man sells a goat and hands the money he received for it to his wife, who goes to the commodities market to buy clothes and food from it. Interviews with key informants confirmed this process.

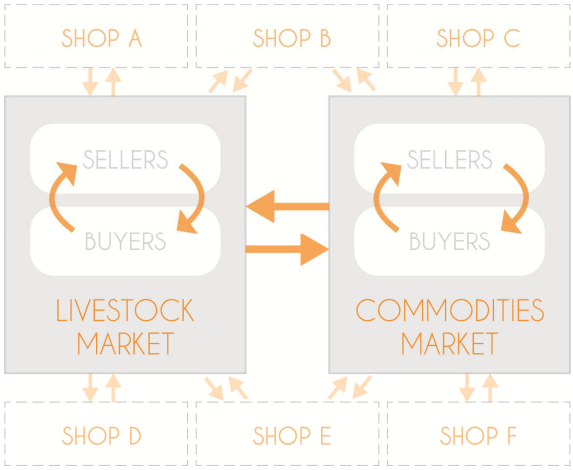

Figure 17: Scheme of money flows between markets (drawn up by the author)

Depending on the livestock market, visitors travel substantial distances to get there. Figure 18 allows us to compare the visitors of both the Bissil and Suswa market in terms of commuting distance. In Bissil, most visitors are in the *> 40 km* category, while most people in Suswa are in the *10 - 20 km* group. In the latter location, 36.2% travels less than 20 km; in the former, 53.1%. This tells us visitors from the Bissil market generally travel longer distances to visit the livestock market. Statistical analysis found the difference to be significant.

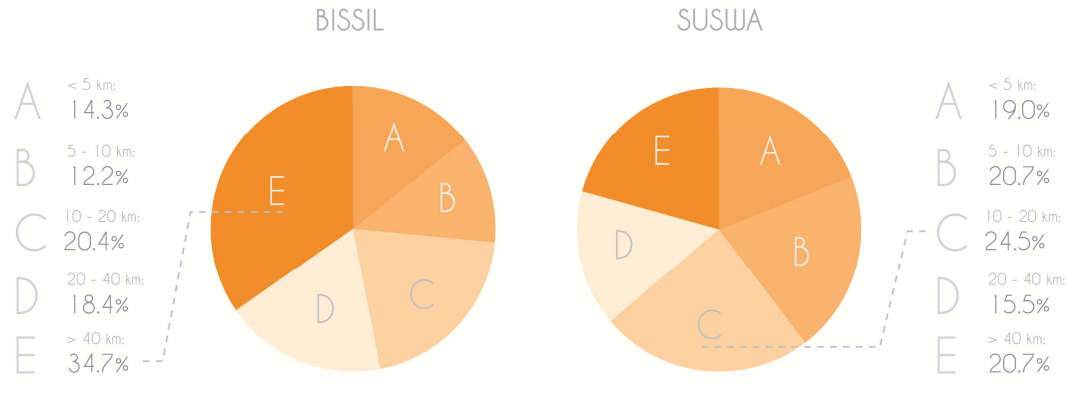

Figure 18: Graph of distance travelled to livestock market

Moreover, visitors of the Bissil market indicated they visit the livestock market more often. This makes sense, since this market is held three times a week - the Suswa market is there only once a week. Respondents in both markets indicated to visit other markets, but both frequency of visits and number of markets visited were found to be comparable in the two research areas (appendix F).

The questionnaire also encompassed questions on payment. Respondents indicated paying for both livestock and commodities in cash in almost all cases. In some cases M-PESA was used to transfer money and a small minority people interviewed mentioned trading livestock for livestock (e.g. a young cow for two goats) or livestock for goods (e.g. bags of maize flower).

Discussion

Based on the results from this study, we can characterize livestock markets as (regional) hubs in pastoralist areas. People are willing to travel large distances to bring their animals to a specific market if they can fetch a high price. This could make secondary livestock markets attractive as RET distribution channels: they might enable dissemination across a wide audience. It is however important to select the most suited market. In this respect, Bissil might be more attractive since its visitors come generally come from further. On the other hand, Suswa attracts more visitors, which might also make it an efficient point of sale.

Visitors of the livestock market buy goods nearby the livestock market with the money earned from livestock sales. One might argue this makes the livestock market, or a nearby shop, an attractive place for dissemination of specific products, like ICS or PSL. In contrast to other types of markets in rural Kenya, the livestock markets deals with large sums of money: a cow can be sold for anywhere between KSh 15,000 and KSh 80,000. This amount of money is more than enough to afford RET.

Reflecting on findings from the literature it is relevant to add that timing is important for distribution. Most rural households value their livestock greatly and do not sell their animals unless there is a good reason. This is why especially January, March and September are good times for RET dissemination, since livestock markets become more active due to the fact that households need money to pay school fees.

4.3 Access to energy technology

4.3.1 Energy products and fuel

As expected, and in line with findings in the literature review, most respondents were used to cooking on three-stone open fires (table 4). For the sake of simplicity the results are presented in such a way that only the main type of cooking, cooking fuel and lighting fuel used is included. Around 80% of respondents indicated to rely solely on firewood; most others relied on a combination of firewood and charcoal. Since firewood is abundant and can be obtained without cost, these results seem to comply with reality. Weekly, households spend on average 6 hours and 38 minutes collecting firewood: this amounts to almost an hour per day. Households that use other fuels seem to pay more Bissil than in Suswa. This contrast was not found to be statistically significant though.

The KCJ is the most common stove for sale and can be bought in both towns. In Bissil a number of shops and kiosks sell these stoves in different sizes and with a price range of between KSh 200 and KSh 400[19]. In the town of Suswa there is only one point of sale - a roadside kiosk - that sells the *jikos* for similar prices as in Bissil. ICS cannot be bought in either locations; only 3.74% of all respondents indicated they owned such a stove of this type.

Electrification rates in rural Kenya are very low; this notion is reflected in the survey results. Almost all people use kerosene for lighting: in total 92.45%. Kerosene is in both study areas sold in the petrol station, where a pump distributes this fuel based on a fixed price per liter. The survey shows that respondents pay significantly more for their kerosene in Bissil than in Suswa, on a weekly basis (appendix C). Respondents indicated either to either make their own lanterns or purchasing kerosene

[19] corresponds to between US$ 2.40 and US$ 4.70 at the time of writing

lamps in larger hardware shops. Kerosene lamps lie in a higher price range than cookstoves: between KSh 650 and KSh 850[20]. PSL are not sold in either Bissil or Suswa. Only 4.72% of respondents indicated their household owned a PSL.

ENERGY	Bissil		Suswa		Total	
	n	descriptive	n	descriptive	n	descriptive
Cookstove used (%)	50		57		107	
3-stone open fire (only)		70.0%		70.18%		70.09%
Rocket stove		0.0%		1.75%		0.93%
Kenya Ceramic Jiko / Metal Charcoal stove		24.0%		22.81%		23.36%
Kuni Bili		0.0%		1.75%		0.93%
Other		2.0%		2.63%		2.80%
ICS		4.0%		2.63%		3.74%
Cooking fuel (%)	50		58		108	
Firewood (only)		78.0%		81.04%		79.63%
Charcoal		20.0%		17.24%		18.52%
Kerosene		2.0%		1.72%		1.85%
Wood collection (hrs) [M/SD]	35	5.47 (4.79)	50	7.46 (6.49)	85	6.64 (331.74)
Cooking fuel spendings [M/SD]	24	328.13 (456.21)	12	268.33 (196.02)	36	308.19 (494.91)
Lighting type used (%)	48		58		106	
Kerosene lantern		93.75%		91.37%		92.52%
Electric		2.08%		6.90%		4.67%
Solar lantern		4.16%		1.72%		2.08%
Lighting fuel spendings [M/SD]	48	384 (384.17)	54	225.56 (114.44)	102	300.20 (331.75)

Table 4: Energy profile

Discussion

This study found that the vast majority of households in still rely on traditional cooking methods. This means that they would benefit from adoption of ICS. Only a small percentage of households owns a modern cookstove or ICS, so there is market potential for this type of product. The same goes for PSL. Almost all households rely on kerosene lanterns; adoption of PSL has the potential to greatly improve their quality of live. When we consider what households spend on a yearly basis, we find an amount of US$ 54.70 in Bissil and US$ 32.14 in Suswa. In Bissil, investing in PSL returns itself in 9 months. In Suswa, this is after a little over 15 months.

[20] Corresponds to US$ 7.72 and US$ 10.09 respectively at the time of writing

Based on the numbers presented in this sub-chapter, both lack of information and availability are factors that might play a role in the fact that RET adoption rates are minimal. Previously in this discussion we have discussed that the price of the Envirofit stove might be an issue. However, it does seem sensible to distribute this type of woodfuel stove in this context. Since most households already use firewood for cooking, this means little change in behavior is necessary.

4.3.2 Awareness of RET

While education rates were low and below average when we consider Kenyan standards, it was found that still people were aware of the benefits of ICS and PSL, to some extent (Figure 19; Figure 20). Perhaps because of previous stove dissemination programs, such as that of the KCJ that started back in the 1980's, respondents knew what to expect from ICS products - even when they might have never seen them.

Respondents were asked if they owned or were familiar with either ICS or PSL and to state the benefits they could name, which the enumerator would then check off from a list (see appendix B). 54.4% of all respondents could name three or more benefits of ICS; 58.2% could give three or more benefits of PSL. Of all participants, 18.7% indicated to know someone owning an improved cookstove; 31.7% knew someone that owned a PSL.

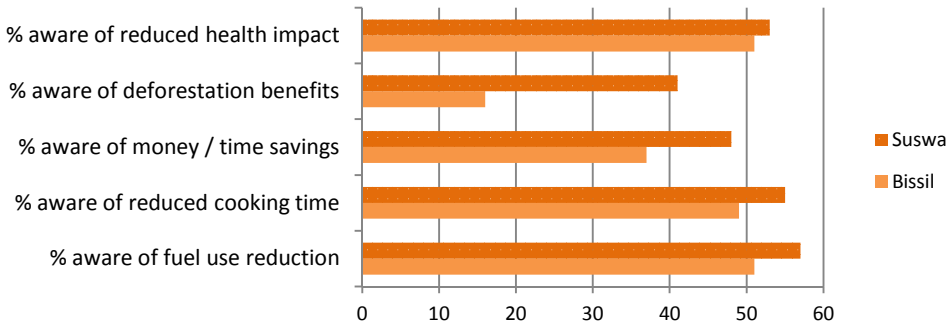

Figure 19: Awareness of benefits of ICS (% of respondents that mentioned specific benefit)

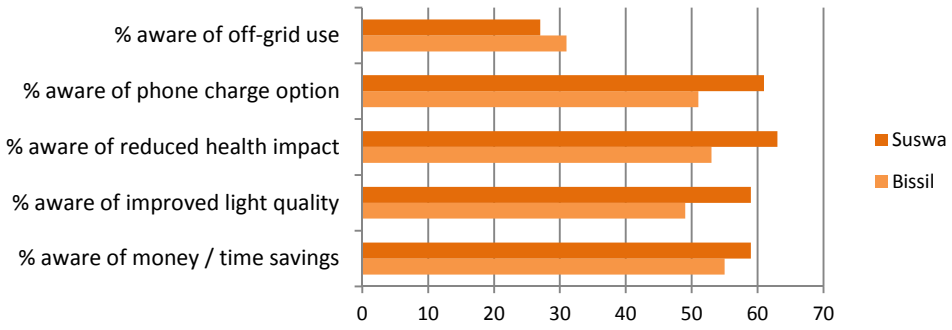

Figure 20: Awareness of benefits of PSL (% of respondents that mentioned specific benefit)

For ICS there was no significant difference found in awareness (appendix D) between men and women. Even though men are better educated, women spend most time around the cookstove, which could explain why awareness is comparable between the two sexes. It was hypothesized (H_0) that men were more aware of the benefits of PSL, since they have more affinity with technology and are better educated. T-testing showed that this in fact was the case (appendix D).

Discussion

As brought forward in the literature review, raising awareness is an important issue. People need to be convinced of the dangers and disadvantages that traditional cooking and lighting bring. While awareness was found to be higher than expected, this is an issue that still needs to be adressed.

Raising awareness in the context of rural Kenya is a challenge. One needs to find the right channels for communication in order to succeed. Schools and hospitals were already mentioned as potential locations for reaching the consumer. Also by means of road shows large audiences can be targeted. In Suswa, a stage was erected to advertize for the painkiller Panadol[21]. GIZ participated in the Kenya Agriculture Show to promote ICS dissemination (A. Ingwe, personal communications, May 22, 2012). We saw that most households own a radio: this might also be a way to reach a wide audience.

[21] As observed in Suswa during field work on May 23, 2012

4.4 Willingness to Pay

4.4.1 Willingness to Pay for RET

A prominent part of the questionnaire involved measuring the respondent's WTP so as to assess the potential for economically viable distribution of ICS and PSL. The determinants for WTP will be analyzed further on in this dissertation in chapter 4.4.2 and 4.4.3 by means of regression analysis.

Firstly, the WTP of the respondent was measured for ICS (appendix B). Figure 21 presents the results in histogram format across the two locations. The graph shows a clear normal distribution. The average WTP in Bissil was KSH 1,340; the average in Suswa was KSh 1,368. This difference was not found to be significant (appendix C). Since incomes are higher in Suswa, and since household own more livestock, it seems logical that the WTP would be somewhat higher in this location.

Although most people indicated a WTP lower than the retail price of KSh 3,500 for the Envirofit G-3300 stove, we can see that there is a small number of respondents that gave a WTP higher than this amount. About 5.7% of the respondents would be willing to pay the actual price of the stove.

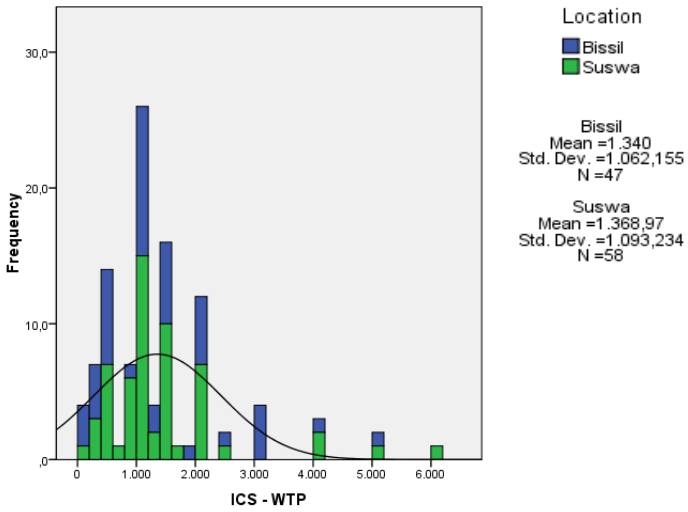

Figure 21: WTP for ICS graph

The WTP graph for PSL is quite dissimilar from the graph above (Figure 22). While we can recognize a normal distribution in the Suswa results, it appears the results from Bissil seem more scattered along the x-axis. From the graph we can learn that in Bissil respondents stated a WTP that was significantly higher than the respondents in Suswa. Of the Bissil respondents, an exceptionally large percentage of 48.0% indicated a WTP higher than the retail price of KSh 3,400, compared to 5.2% in Suswa.

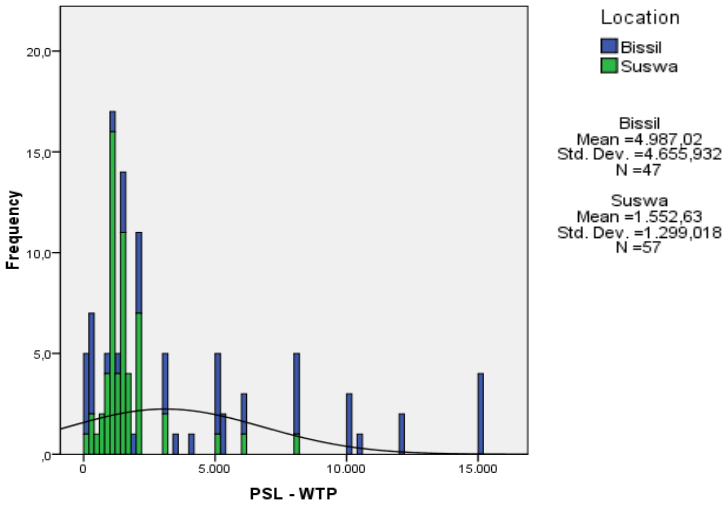

Figure 22: WTP for PSL graph

In the literature review we discussed that allowing the consumer to pay through an installment might make RET considerably more attractive, especially to low-income households. Result from the survey confirm this. For ICS, the respondent's WTP increased by 119.13%, when presenting the option for payment over the course of 12 months. For PSL this percentage amounted to 71.48%.

Discussion

The survey attempted to measure WTP for RET across the two locations. A remarkable finding was that WTP for PSL differed significantly across the two locations. Perhaps we can attribute this disparity to cultural factors. Based on findings from the survey and observation studies however, this seems unlikely. Both locations are very similar in organization, as well as in geographic context. Suswa and Bissil are both located about an hour drive away from Nairobi and connected to a highway. Exposure to urban dwellers, tourists and technology seems limited and comparable in both locations.

A number of H_0 hypotheses were constructed and tested by means of t-tests in order to explain the disparity in WTP between Suswa and Bissil. Neither education, age, gender nor family size were found to be significantly different between the two sites (appendix C, E). However, across the two locations and the two WTP groups (group 0: WTP < KSh 3,400; group 1: WTP => KSh 3,400) it was found that weekly lighting fuel spending was higher in Bissil and in group 1. With higher lighting fuel spendings, adopting PSL will deliver more (absolute) savings. This could be a plausible explanation why PSL might be more attractive for households in Bissil.

Another suggestion is that households in Bissil have more need for PSL. After all, in chapter 4.1.2 we learned that incomes are lower in this location. Households spend a larger share of their monthly budget on lighting fuel, which means adoption of PSL would contribute greatly to their livelihoods. On the other hand, one could argue that perhaps household in Suswa that have higher incomes perceive PSL products as inferior goods. They would rather own a Solar Home System (SHL), which can power their lights or televisions, which could result in a lower WTP for PSL.

A final hypothesis that could explain the difference in WTP for PSL between Bissil and Suswa has to do with the finding that respondents in the former site seemed to own more technological assets. This could imply that people in this Bissil value technology higher. This is a tentative suggestion however. More research will have to be carried out in order to back up this claim.

According to the results from primary data collection and CVM it seems that distribution of RET through livestock markets is, at least in theory, viable. Of course we have to consider the limitations of this study; further research is necessary to obtain more robust results. However, when we look at Figure 21 and Figure 22, we see there certainly is demand for RET. For one, almost all respondents were *willing to pay* for both RET[22]. Furthermore, from Figure 23 we can learn in how many cases the respondent stated a WTP higher than the retail price. In theory, all cases outside of the orange square represent a respondent that would purchase one or both proxy RET products, if it was available for sale. In total we are talking about 28.0% of all cases, which is a substantial amount.

According to this research WTP to pay for RET increases when giving the consumer the opportunity to pay through an installment. Therefore it seems sensible for the distributer to look into what the possibilities are to achieve this. Since Kenya's rural population is often unbanked or without official identification papers this is not a simple task. A solution might be found by cooperating with banks or SACCO's to make financial arrangements.

[22] 98.15% of respondents stated a WTP > 0 for either PSL or ICS

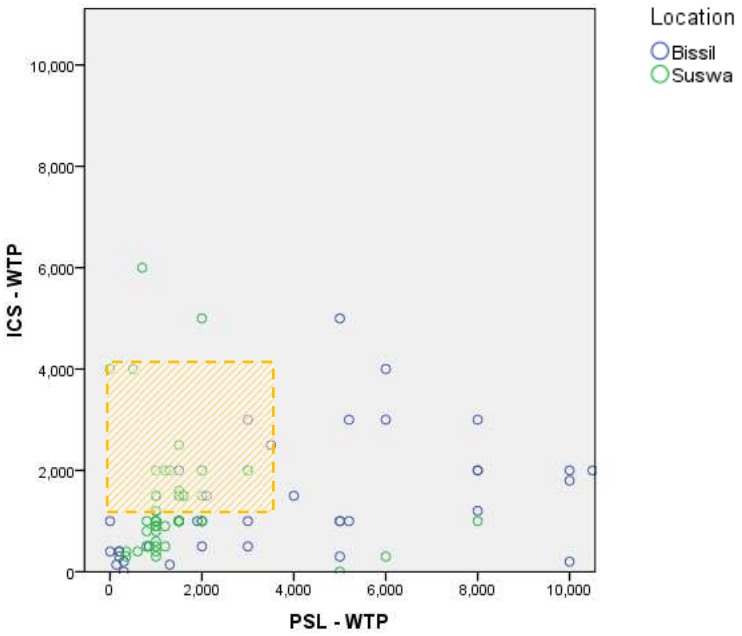

Figure 23: Scatter plot WTP for ICS / PSL

Whether this distribution model will efficiently target the BOP remains questionable. It seems unlikely that the poorest households would spend between one third and half of their monthly budget on either ICS or PSL[23]. The successful KCJ dissemination program offered stoves for between around US$ 5. GIZ distributed over 1.3 million cookstoves that had a similar retail price. A distribution plan that aims to sell these products for three times that price might not be exceptionally thriving. Based on the findings from this research it seems more likely a smaller segment of the market would be willing and able to purchase the RET products selected for distribution by React Africa.

4.4.2 ICS regression analysis

Regression analysis was used to further analyze the success factors for RET dissemination. We apply this technique in order to uncover the determinants for WTP. In combination with findings from the literature review the results from regression analysis enable us to assess how to overcome barriers for distribution.

[23] Here, we refer to the proxy RET products React Africa means to distribute

Takema et al. (2007) found that education, income, household size and lifestyle factors are relevant factors that play a role in a households willingness to adopt RET. Based on findings from the literature, results from the survey and statistical tests (t-test; chi-square tests), the following model was constructed to explain WTP for ICS:

$$WTP_{ICS} = \widehat{\beta_0} + \widehat{\beta_1}\,[location] + \widehat{\beta_2}[age] + \widehat{\beta_3}[gender] + \widehat{\beta_4}\,[education] + \widehat{\beta_5}\,[no.of\ children] + \widehat{\beta_6}\,[income] + \varepsilon_7\,[residual] \quad (3)$$

Regression WTP_{ICS}				
Variable	**WTP (1)**	**WTP (2)**	**WTP (3)**	**WTP (4)**
Location (Suswa)	-140.684 (-0.589)	-137.415 (-0.585)	-	-
Age	-3.998 (-0.370)	-4.878 (-0.441)	-	-7.721 (-0.771)
Gender (male)	-115.340 (-0.444)	-94.543 (-0.353)	-59.909 (-0.204)	-52.772 (-0.224)
Education	127.359 (0.918)	117.466 (0.787)	-	-
No. of children	52.844 (1.850)***	53.013 (1.794)***	53.567 (1.869)***	33.827 (1.072)
Income	-0.004 (-0.406)	-0.002 (1.120)	-0.003 (-0.033)	
No. of goats owned	-	-	-	-0.670 (-0.120)
Awareness	-	71.748 (1.1230)	-	67.880 (1.122)
Time spent gathering fuel	-	-	-25.363 (-1.164)	-
Stove owned (yes)	-	-	-	516.354 (2.092)**
n	97	97	79	93
R^2 (adjusted)	-0.022	-0.027	-0.011	0.023

* Significant at 10% level ** significant at 5% level *** significant at 1% level

Table 5: Regression results WTP for ICS (t-value between parentheses)

It remains doubtful whether the regression models presented in the table above accurately describe the determinants for WTP for ICS. We can read from this table that the adjusted R^2-values seem are quite low or even negative in the case of the first three models. Perhaps this means the determinants for WTP are, in this case, not clear cut and that the relationships between the regression coefficients in reality are more complex. Another suggestion might be that a linear regression model oversimplifies the properties of determinants.

After a set of modifications in the original composition the WTP_4 model was found to be most robust, with a adjusted R^2-value of 0,023:

$$WTP_{ICS} = \widehat{\beta_0} + \widehat{\beta_1}\,[age] + \widehat{\beta_2}\,[gender] + \widehat{\beta_3}[no.of\ children] + \widehat{\beta_4}[no.of\ goats\ owned] + \widehat{\beta_5}\,[ICS\ awareness] + \widehat{\beta_6}\,[stove\ owned] + \varepsilon_7\,[residual] \quad (4)$$

In this model (WTP_4) *education* was dropped as an Independent Variable, since it was found to strongly correlate with *gender* (e.g. men are significantly better educated than women) (appendix G). *Location* was taken out since t-testing indicated there was no significant difference in WTP across the two locations and it was found to correlate with *number of children* (e.g. in Suswa families include higher numbers of children). *Time spent gathering fuel* was omitted, since the model refuted the H_0 hypothesis that the more time a household spends gathering cooking fuel, the more it would have need for ICS. Lastly, *income* was replaced with *number of goats owned* to test whether livestock might replace the function of currency in this context.

According to the literature it was assumed that the following determinants: *number of children, no. of goats owned, ICS awareness* and *stove owned* are all positively related to WTP: a higher value would result in a higher WTP (Bailis et al., 2009; Troncoso et al., 2011; Schlag and Zuzarte, 2008). *Age* and *gender*, on the other hand, were expected to be negatively influence a household's WTP for ICS. Based on Schlag and Zuzarte (2008) it was expected that women would have more interest in adoption of ICS than men, since they are primarily in charge of cooking.

Two coefficients were found to be significant as determinants for WTP across the four models: *number of children* (significant at $p < 0.05$), *stove owned* (significant at $p < 0.05$). These two determinants were not detected to be significant in the same model, which again illustrates the limitations of this model.

Discussion

It must be stressed that the models constructed to find the determinants for WTP for ICS lack in robustness. Further research is needed to reassess the statistical quality of the presented analysis.

When we consider the fourth regression model we see that, although only one determinant is found to be significant, most determinants contribute to WTP as presumed (e.g. older people have a reduced WTP). However, the model refutes the H_0 hypothesis that households with a higher *no. of goats owned* have a higher WTP. The single significant determinant resulting from this analysis describes that households that already own a stove have a higher WTP for ICS. In line with what the literature says about the success of the KCJ dissemination program we propose that people that are already used to paying for and working with a stove might be more inclined to adopt ICS (Bailis et al., 2009). If this is true, it could be argued that market activation activities should target especially stove owners. Considering the robustness of the model however this is a tentative suggestion.

In models WTP_1, WTP_2 and WTP_3 *no. of children* is found to be the only significant determinant for WTP. When we consider the health impacts of cooking over a three-stone open fire we can explain this: children are, along with women, most affected by IAP. Furthermore, when you have a big family with many children, you cook more often. Since adoption of ICS facilitates time and monetary savings it would make sense to invest. Conversely, we should take note that WTP_1, WTP_2 and WTP_3 are inferior to WTP_4 in terms of statistical power.

4.4.3 PSL regression analysis

Since WTP for PSL differed significantly across the two locations it is particularly interesting to look into the assembly of a model that can explain this. The following formula presents the model from which we started out our regression analysis:

$$WTP_{PSL} = \widehat{\beta_0} + \widehat{\beta_1}\,[location] + \widehat{\beta_2}[age] + \widehat{\beta_3}[gender] + \widehat{\beta_4}\,[education] + \widehat{\beta_5}\,[no.of\ children] + \widehat{\beta_6}\,[income] + \widehat{\beta_7}\,[PSL\ awareness] + \varepsilon_8\,[residual] \quad (5)$$

A number of regression tests were done to investigate the determinants for Willingness to Pay for PSL (table 6). The following composition of regression coefficients seemed to deliver the most robust model (WTP_4) with an adjusted R^2-value of 0.319:

$$WTP_{PSL} = \widehat{\beta_0} + \widehat{\beta_1}\,[location] + \widehat{\beta_2}[age] + \widehat{\beta_3}\,[age^2] + \widehat{\beta_4}\,[education] + \widehat{\beta_5}\,[no.of\ children] + \widehat{\beta_6}\,[income] + \widehat{\beta_7}\,[PSL\ awareness] + \varepsilon_8\,[residual] \quad (6)$$

Regression WTP_{PSL}				
Variable	**WTP (1)**	**WTP (2)**	**WTP (3)**	**WTP (4)**
Location (Suswa)	-3909.054 (-5.734)***	-3686.146 (-4.970)***	-3902.939 (-5.803)***	-3982.541 (-5.987)***
Age	-71.541 (-2.353)**	-84.511 (-2.601)**	253.582 (1.396)	223.127 (1.255)
Age^2	-	-	-3.886 (-1.815) *	-3.509 (-1.678)*
Gender (male)	364.931 (0.486)	500.715 (0.648)	647.549 (0.855)	-
Education	-324.049 (-0.775)	-352.225 (-0.070)	-376.889 (0.911)	-321.633 (-0.788)
No. of children	129.009 (1.623)	166.214 (1.811)*	131.807* (1.681)	137.293 (1.759)*
Income	-0.013 (-0.461)	-0.019 (-0.620)	-0.023 (0.779)	-0.016 (-0.571)
Lighting fuel spendings	-	1.034 (0.990)	-	-
Awareness	491.917 (2.657)***	527.060 (2.653) ***	503.108 (2.753) ***	522.300 (2.885)***
N	91	87	91	91
R_2 (adjusted)	0.298	0.295	0.317	0.319

* Significant at 10% level ** significant at 5% level *** significant at 1% level

Table 6: Regression results WTP for PSL (t-value between parentheses)

In this regression model *location*, *age*, *age*^{2}, *education*, *number of children*, *income* and *awareness of the benefits of PSL* were included as IVs. The IV *gender* was taken out, since it was found to correlate strongly with education (men are significantly more educated than women) and awareness (men have a higher awareness of the benefits of PSL) (appendix G).

According to the literature we expect that *education*, *number of children, income and PSL awareness* are all positively related to WTP (Bailis et al., 2009; Schlag and Zuzarte, 2008; Ingwe, 2012). *Location* was expected to negatively influence WTP, since the survey results pointed out that respondents in Bissil generally had a higher WTP. For *age* we anticipated a parabolic relation with WTP, hence the variable age^2.

The determinants *location* (significant at $p < 0.01$), *age*^{2} (significant at $p < 0.1$), *number of children* (significant at $p < 0.1$) and *awareness of PSL benefits* (significant at $p < 0.01$) were found to be significant.

Discussion

Compared to the WTP_{ics} model, the WTP_{psl} model is considerably more robust. Since 4 out of 7 predicting variables are significant, the model has more potential to give insight into the determinants for WTP for PSL.

Location was found to be a significant determinant for a higher WTP. This is not surprising since we had already learned that respondents in Bissil indicated to be willing to pay significantly more for PSL. In sub-section 4.4.1 a number of suggestions were made as to explain this. It was suggested that perhaps cultural factors are involved or that people in Bissil perhaps might be more interested in technology, which would explain their higher WTP. This tell us that it would be sensible to select appropriate locations for RET distribution. Market research has to point out which sites qualify.

In linear regression we assume linear relationships. Age^2 was found to be a significant factor in our model, which could indicate that the relationship between age and WTP in fact is parabolic. It was found that until age 31,79 people are willing to pay an increasing amount for PSL (appendix H; Figure 24). After this age WTP decreases. A possible explanation could be that people tend to earn more as they get older, until a certain point. After a certain age, income goes down again, due to, for example, a decrease in productivity. Other reasons could comprise that people accumulate more knowledge and awareness over time, but in time become more conservative and less open to innovations and modernization.

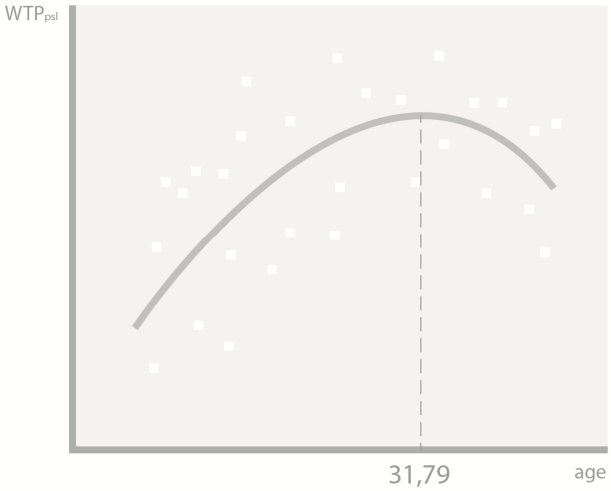

Figure 24: Graph describing relation age / WTPpsl

One might argue that a *higher no. of children* contributes to an increased WTP for PSL, since with more children the household also benefits more. Mothers have more time to tend to their children (e.g. before and after sunset). Moreover, children can enjoy longer hours of studying. Another suggestion involves the notion that families with more children have more expenses; adopting the use of PSL could bring them considerable savings to make up for this.

Lastly, *awareness of the benefits of PSL* was found to be significant as a determinant in this regression model. When the target population realizes what health impacts can be avoided, the money they can save and the improvement in quality of light a PSL delivers, it seems logical that their WTP will go up. This implies raising awareness and educating communities through different communication channels can have effect and actually have the potential to mobilize households to invest.

5. Conclusions & Recommendations

5.1 Conclusions

In this dissertation we discussed the gravity of the issue we know as energy poverty. Lack of access to modern energy facilities hampers the development of especially the Bottom-Of-the-Pyramid. In rural Kenya, where electrification rates are low, households are effected by severe economic, social and health impacts due to their dependency on biomass and kerosene fuels. Moreover, the large-scale use of wood and charcoal can also be connected to environmental issues, such as deforestation and climate change.

Renewable Energy Technology has the potential to greatly improve the livelihoods of BOP households in Sub Saharan Africa. The traditional way of cooking, on a three-stone open fire, is inefficient and produces dangerous smoke. Improved Cookstoves reduce health impacts and eliminate the need to spend long hours collecting firewood. Although some literature contests this, ICS can also reduce cooking time. Another RET innovation, the Photovoltaic Solar Lantern, has the potential to replace the traditional kerosene lantern. PSL uses sunlight to generate the energy that is needed to produce light. Households that adopt the use of PSL no longer need to spend a large part of their budget on kerosene. Moreover, PSL produce light of superior quality and in contrast to kerosene lanterns, do not produce harmful fumes.

In order to distribute RET to the BOP in rural Kenya it is important to overcome a range of market barriers. First and foremost, educating the target consumer on the dangers of traditional lighting and cooking is an important task. This activity, market activation, should also involve educating local communities on the benefits of RET, on how to use ICS and PSL, and on where to buy these products. In order to achieve sustained adoption of RET, the products selected for distribution need to comply with the target population's cultural and social standards. Production and R&D of RET is more expensive than the locally manufactured stoves, so price competitiveness is a crucial aspect of both ICS and PSL dissemination. Infrastructure in SSA is generally poor, which is problematic since it can make distribution increasingly difficult and expensive. Lastly, structural complications, such as the notion that households often do not have savings, or are not willing to make investments that will be returned over time, are obstacles that have to be overcome.

For a variety of reasons it was hypothesized that livestock markets are suitable places to RET distribution. By means of quantitative and qualitative data collection the potential of livestock markets for economically viable dissemination of ICS and PSL products in pastoralist Kenya was assessed. Two secondary livestock markets were appointed as study areas. By means of a survey and key informant interviews data was collected on the target sample group.

The outcome from the questionnaire was used to construct a profile of the target consumer. The results show that most people, in fact, depend on traditional lighting and cooking methods. The vast majority of households cooks solely with fuelwood. Adoption rates of ICS and PSL were found to be very low and most respondents had never come across a RET product. Education rates were low in both locations, but still a significant amount of respondents were aware of the benefits of RET, to some extent. Most likely we can attributed this to the success previous dissemination programs such as that of the *Kenya Ceramic Jiko*.

In both locations incomes were found to be low; especially in Bissil. However, respondents indicated to own large amounts of livestock, which implies that we are technically not dealing with the BOP. Even though the mobile banking solution M-PESA is picking up in Rural Kenya, most household do not have substantial savings. This is a barrier for adoption of RET. Especially the Envirofit G-3300 stove and the Trony Solar Sundial TS-01, that React Africa aspires to distribute, have a high retail price that might scare off low-income consumers.

Contingent Valuation Method was employed to assess the demand for RET. The average *Willingness To Pay* for ICS comprised KSh 1,340 in Bissil and KSh 1,368 in Suswa. For PSL the mean WTP of KSh 4,987 in Bissil was found to be significantly higher than in Suswa, where the mean WTP was only KSh 1,552. Nearly all participants were, to some extent, interested in purchasing RET. Of all respondents 28,0% stated a WTP higher than the retail price. The majority of respondents indicated a higher WTP when given the option to pay off the product through an installment.

Regression analysis was applied to describe the determinants for WTP in order to analyze which factors influence the success of RET distribution. While the assessed regression model lacked in robustness, *number of children* and *stove owned* were found to be possible factors influencing WTP_{ICS}. More likely a strong interplay of different variables contribute to one's WTP for ICS. On the other hand, the regression model for WTP_{PSL} that comprised *location*, *age*, age^2, *number of children*,

income and *awareness of PSL benefits*, was found to be more robust. The significant determinants were *location*, age^2, *number of children* and *awareness of PSL* benefits. Further research is needed to explain why WTP_{PSL} is higher in Bissil. Possible suggestions for this include the finding that lighting fuel spendings are higher in Bissil, or that people in this location have less income and therefore have more need for PSL.

It was found that (secondary) livestock markets might be suitable places for RET distribution, although it remains questionable whether they are the most efficient place for targeting BOP households. A trade-off seems to arise: it is possible to either distribute a more expensive product to a small high-income consumer group, or to reach a wider audience with a more affordable product. The latter option seems more suitable when aiming to alleviate energy poverty. However, it must be noted this dissertation only comprises exploratory research. To further assess the potential of RET distribution through livestock markets more research is needed into the dynamics of the market, behavior of the consumer and the determinants behind WTP for RET.

5.2 Recommendations

This study found that economically viable dissemination of RET from livestock markets in rural Kenya seems to have potential. However, for the distributor it would make sense to look into a number of factors that could catalyze the adoption of RET.

Market activation and education the target population on the benefits of RET are essential activities that have to take place before staring distribution. Additional studies will have to point out how to efficiently target the consumer. Interviews with key informants taught us that local actors can play a large role in this process. Involving local actors has more advantages: it enhances the acceptability of the dissemination program and contributes to local economies.

While in both study areas there seemed to be demand for RET, further research has to be completed in order to determine whether the products, as selected by React Africa, are suitable for distribution to the BOP. Both affordability and compatibility with cultural and technical preferences are aspects that have to be assessed further. Working together with SACCO's or banks in order to allow the consumer to pay through an installment can make RET significantly more attractive. Furthermore, distributing stoves that were designed in collaboration with local artisans could be a potential success factors for wide-scale adoption.

Further market research will have to take place in order to evaluate which locations might be most suitable for distribution. Based on the results of this study it remains questionable whether secondary livestock markets are appropriate locations for targeting the BOP consumer. It must be said this research was limited in scale and took place in only two, semi-arid locations in Southern Kenya. Therefore, further exploratory studies across Kenya are necessary.

Due to the dynamics of the livestock market there are specific periods over the course of a year that could enable more efficient distribution of RET. When school fees have to paid, trading activities intensify. This means households will have more money to spend. Additional research will have to prove the assumption that these periods qualify as the ideal time for entering the market.

The final recommendation presented here relates to the role after-sale services play. Especially with more technological products, like the RET discussed in this dissertation, it is essential that there is an information, reparations and maintenance point available for those who already have or are interested in adopting RET. Again, local actors are most suitable for this function since they are more accessible and appear more credible to the target consumer.

Bibliography

Literature

Abdullah, S., Jeanty, P. (2011) Willingness to Pay for renewable energy: evidence from a contingent valuation survey in Kenya, *Renewable and Sustainable Energy Reviews*, Vol. 15, p. 2974 - 2983

Abdullah, S., Markandya, A., (2011) Rural electrification programs in Kenya: Policy conclusions from a valuation study, *Energy for sustainable development,* Vol. 16, p. 103-110

Apple, J., Vicente, R., Yarberry, A., Lohse, N., Mills, E., Jacobson, A., Poppendieck, D., (2010) Characterization of particulate matter size distributions and indoor concentrations from kerosene and diesel lamps, *Indoor Air*, Vol. 20, p. 399–411

Bailey, D., Barret, C. B., Little, P. D., Chabari, F. (1999) Livestock markets and risk management among East African pastoralists: a review and research agenda, Available at: http://ssrn.com/abstract=258370

Bailis, R., Ezzati, M., Kammen, D., M., (2003) Greenhouse Gas Implications of Household Energy Technology in Kenya, *Environmental Science & Technology*, Vol. 37, p. 2051-2059

Bailis, R., Jacobson, A., Kirubi, C., (2006) Searching for sustainability: Kenya's energy past and future, *ACTS working paper*

Bailis, R., Cowan, A., Berrueta, V. (2009) Arresting the Killer in the Kitchen: The Promises and Pitfalls of Commercializing Improved Cookstoves, *World Development*, Vol. 37, No. 10, pp. 1694–1705

Bala, G., Caldeira, K., Nemani, R. (2010) Fast versus slow response in climate change: implication for the global hydrological cycle, *Climate Dynamics*, Vol. 35, No. 2-3, p. 423-434

Banerjee, A. V., Duflo, E. (2007) The economic lives of the poor, *Journal of Economic Perspectives,* Vol. 21, no. 1, p. 141–167

Barnes, B., Mathee, A., Thomas, E., Bruce, N. (2009) Household energy, indoor air pollution and child respiratory health in South Africa, *Journal of Energy in Southern Africa*, Vol. 20, No. 1, p. 4-13

Beukering, P. van, Brouwer, R., van der Kroon, B., (2011) The energy ladder: Theoretical myth or empirical truth? Institute for Environmental Studies, available at: http://www.renew-is-academy.org/p/research-and-publications.html

Birol, F. (2007) Energy economics: a place for energy poverty on the agenda?, *The Energy Journal,* Vol. 28, no. 3, p. 1-6

Brew-Hammond, A. (2009) Energy access in Africa: challenges ahead, *Energy Policy, Vol.* 38, p. 2291-2301

Dutta, S. (2002) Energy as a key variable in eradicating extreme poverty and hunger: a gender perspective on empirical evidence on MDG #1, *Energy Policy,* Vol. 30, p. 1059-1069

ESMAP, Energy Sector Management Assistance Program (2010) Improved Cookstoves and better health in Bangladesh: Lessons from household energy and sanitation programs. *ESMAP report*

Dekking, F. M., Kraaikamp, C., Lopuhaä, H. P., Meester, L. E. (2005) A modern introduction to probability and statistics, Springer, Londen, p. 399-413

Envirofit (2012) Envirofit 2012 product overview, available at: http://www.envirofit.org/overview/

Ezzati, M. (2004) Indoor air quality in developing nations, *Encyclopedia of energy*, Vol. 3, p. 343 -350

Field, A. (2005) Discovering statistics using SPSS, Sage, London, 2nd edition, p. 143-217

Fratkin, E., Mearns, R. (2003) Sustainability and Pastoral Livelihoods: Lessons from East African Maasai and Mongolia, *Human Organization*, Vol. 62:, No. 2

Fujiate, Y., Fujii, A., Furukawa, S., Ogawa, T., (2005) Estimation of Willingness-to-Pay (WTP) for Water and Sanitation Services through Contingent Valuation Method (CVM) - A Case Study in Iquitos City, The Republic of Peru, *JBICI Review*, no. 11, p. 59-87

García-Frapolli, E., Schilmann, A., Berrueta A. V., Riojas-Rodríguez, H., Edwards, R.D., Johnson M., Guevara-Sanginés, A., Armendariz, C., Masera, O. (2010) Beyond fuelwood savings: Valuing the economic benefits of introducing improved biomass cookstoves in the Purépecha region of Mexico, *Ecological Economics*, Vol. 69, p. 2598–2605

Global Alliance for Clean Cookstoves (2011) Igniting Change: A Strategy for Universal Adoption of Clean Cookstoves and Fuels, available at: http://www.cleancookstoves.org

GOK, Government of Kenya (2012) Feed-in tariffs policy on wind, biomass, small-hydro, geothermal, biogas and solar resource generated electricity, available at: http://www.energy.go.ke/wp-content/uploads/2010/08/feed%20in%20tarriffs.pdf

Gradl, C., Knobloch, C. (2011) Energize the Bop: Energy Business Model Generator for Low-Income Markets, available at: http://www.energize-the-bop.net/fileadmin/energize-the-bop/Endeva_ Energize_the_BoP_energy_Business_Model_Generator _2011.pdf

Hiemstra-van der Horst, G., Hovorka, A. (2009) Fuelwood: The "other" renewable energy source for Africa, *Biomass and Bioenergy*, Vol. 33, p. 1605-1616

Homewood, K., Trench, P. C., Kristjanson, P. (2009) Staying Maasai? Pastoral livelihoods, diversifications and the role of wildlife in development, *Studies in Human Ecology and Adaptation*, Vol. 5, Part 4, p. 369-408

Kebede, E., Kagochi, J., Curtis, J. M. (2010) Energy consumption and economic development in Sub-Saharan Africa, *Energy Economics,* Vol. 32, p. 532-537

Kiplagata, J.K., Wanga, R.Z., Li, T.X., (2011) Renewable energy in Kenya: Resource potential and status of exploitation, *Renewable and Sustainable Energy Reviews*, Vol. 15, p. 2960– 2973

Limão, L., Venables, A. (2004) Infrastructure, geographical disadvantage, transport costs, and trade, *The World Bank Economic Review*, Vol. 15, No. 3, p. 451-479

Mahapatra, S., Chanakya, S., Dasappa, S., (2009) Evaluation of various energy devices for domestic lighting in India: Technology, economics and CO2 emissions, *Energy for Sustainable Development,* Vol. 13, p. 271 – 279

Mahmoud, M. (2011) Livestock Marketing Chains in Northern Kenya: Re-Aligning Exchange Systems in Risky Environments, *Economic spaces of pastoral production and commodity systems*, p. 127-150

Morawczynski, O., Miscione, G. (2008) Examining trust in mobile banking transactions: the case of M-PESA in Kenya, *IFIP International Federation for Information Processing*, Vol. 282, p. 287–298

Morawczynski, O. (2009) Exploring the usage and impact of "transformational" mobile financial services: the case of M-PESA in Kenya, *Journal of Eastern African Studies*, Vol. 3, Issue 3, p. 495-503

Mills, E., Jacobson, A. (2011) From carbon to light: a new framework for estimating greenhouse gas emissions reductions from replacing fuel-based lighting with LED systems, *Energy Efficiency*, Vol. 4, p. 523-546

Muzee, K., (2011) Low-carbon Africa: Kenya, Low-Carbon Africa: Leapfrogging to a Green Future

Mwampamba, T. H. (2007) Has the fuelwood crisis returned? Urban charcoal consumption in Tanzania and its implication to present and future forest availability*, Energy Policy*, Vol. 35, no. 8, p. 4221-4234

Peck, M.D., Kruger, G. E., (2008) Burns and fires from non-electric domestic appliances in low and middle income countries, *Burns 34*, p. 303 – 311

Practical Action Consulting in Eastern Africa (2010) Bioenergy and poverty in Kenya: attitudes, actors and activities, *working paper prepared for PISCEP*

Prasal, G (2008) Energy sector reform, energy transitions and the poor in Africa, *Energy Policy*, Vol. 36, p. 2806– 2811

Quadir, S. A., Mathur, S. S., Kandpal, T. C. (1995) Barriers to dissemination of renewable energy technologies for cooking, *Energy Conversion Management*, Vol. 36, No. 12, p. 1129-1132

Rowe, R. D. (1996) A test for payment card biases, *Journal of Environmental Economics and Management*, Vol. 31, p. 178-185

Schlag, N., Zuzarte, F., (2008) Market barriers to clean cooking fuels in Sub-Saharan Africa: a review of literature, Stockholm Environment Institute

Sequino, S. (2010) Gender, distribution, and balance of payments constrained growth in developing countries, *Review of Political Economy*, Vol. 22, No. 3, p. 373–404,

Takama, T., Lambe, F., Johnson, F. X., Arvidson, A., Atanassov, M., Debebe, M., Nilsson, L., Tella, P., Tsephel, S. (2011) Will African consumers buy cleaner fuels and stoves? *Research report*, SEI, Stockholm Environmental Institute

Tietenberg, T., Lewis, L., (2010) Environmental Economics and Policy, chapter 20, *Development Poverty and the Environment*

Torres-Duge, C., Maldonado, D., Pérez-Padilla, R., Ezzati, M., Viegi, G. (2008) Biomass fuels and respiratory diseases, *Proc Am Thorac Soc*, Vol. 5, p. 577-587

Troncoso, K., Castillo, A., Merino, L., Lazos, E., Masera, O. R., (2011) Understanding an improved cookstove program in rural Mexico: An analysis from the implementers' perspective, *Energy Policy*, Vol. 10, p. 1016

Victor, B. (2011) Sustaining Culture with Sustainable Stoves: The Role of Tradition in Providing Clean-Burning Stoves to Developing Countries, *Consilience: The Journal of Sustainable Development*
Vol. 5, Issue 1, p. 71-95

Whittington, D. (1998) Administering Contingent Valuation surveys in developing countries, *World Development*, Vol. 26, No. 1, p 21-30

World Bank, The (2011) Household cookstoves: environment, health, and climate change, available at: http://climatechange.worldbank.org/content/cookstoves-report

Websites

CIA Factbook (2012) https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html, accessed on: 13 June 2012

EPA, Environmental Protection Agency (2012) http://www.epa.gov/cleanenergy/energy-resources/refs.html#coalplant, Clean energy calculator, accessed on: 25 June 2012

LMISKE, National Livestock Market Information System (2012) http://www.lmiske.net/, by Kenyan ministry of livestock, accessed on: 13 July 2012

World Bank (2012) http://data.worldbank.org/country/kenya, accessed on: 10 June 2012

Personal communications

Ingwe, A. (2012) Verbal communications with the author on May 22, 2012, GIZ Nairobi office

Gema, J., Principal Consultant React Africa (2012) Verbal communications with the author on May 30, 2012, SNV South Rift Portfolio office

Maesya, M., Abdi, A. (2012) Verbal communications with the author in May 2012, SNV South Rift Portofolio office

Kitala, J. (2012) Verbal communications with the author in May 2012, SNV South Rift Portfolio office

Appendix A

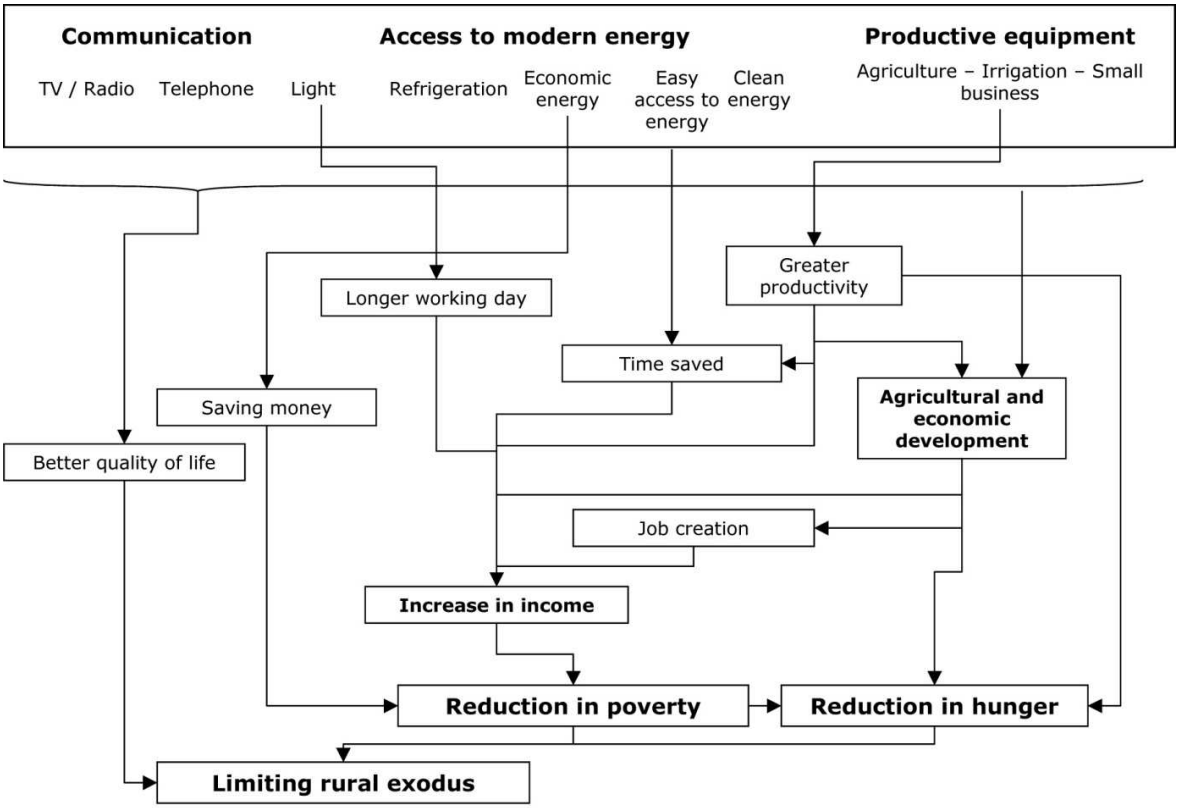

Figure 1 Connection between energy and quality of quality of life (source: Dutta, 2002)

Appendix B

Questionaire

Interviewer:
Date of interview:
Time of interview:
Time at end of interview:
Location:
Questionaire no.:

Instruction for the interviewer
- Interview only people that are 18 years and older
- Interview only visitors of the livestock market (e.g. no cattle traders / shop owners)
- Try to interview an equal number of men and woman
- When respondent cannot give a precise answer try to get an estimate
- In case of numeric response try to get actual value – otherwise use categories
- Unless stated otherwise - only one answer should be noted down
- Introduce yourself before starting the interview and give an introduction to the research
- Communicate that this research is meant to benefit the community
- Communicate that participation of this survey is voluntary
- Communicate that this survey is completely anonymous and confidential
- Use this form to get answers (e.g. show respondent from what options he/she can choose)

Introduction:
We are doing research for the Dutch Development Organization (SNV) and the Free University of Amsterdam on energy needs, fuel use and demand for energy products in pastoral areas. Your participation is important and very much appreciated. The conclusions derived from this research may help us to improve the distribution of energy products in pastoral areas. The questionnaire will take around 20-30 minutes. All responses are completely anonymous and will only be used for the purpose of this study. Please answer as truthful as possible. If you are ready, let us begin.

Part 1:

1) What is your age? …….. years old

2) What is your gender? ☐ (0) Male ☐ (1) Female

3) Where do you live? ……

3b) How many kilometer is that from here? ……

☐ (0) 0-5 km ☐ (1) 5-10km ☐ (2) 10-20km ☐ (3) 20-40km ☐ (4) >40km

4) What is your main occupation?

☐ (0) Farming ☐ (1) Livestock ☐ (2) Dairy
☐ (3) Trading ☐ (4) Artisan ☐ (5) Salaried employment
☐ (6) Casual labor ☐ (7) Other, namely ……

5) What is the highest level of education you have completed?

☐ (0) Did not go to school ☐ (1) Primary school
☐ (2) Secondary school ☐ (3) College
☐ (4) University ☐ (5) Other, namely ……

6) What is your connection to the head of the household:

☐ (0) Head ☐ (1) Husband / Wife ☐ (2) Child / Adopted child
☐ (3) Grandchild ☐ (4) Brother / Sister ☐ (5) Brother-in-law / Sister-in-law
☐ (6) Maid / Nanny ☐ (7) Other, namely ……

7) How many in your household excluding you?
…… children under 18
…… women <u>over</u> 18
…… men over 18

8) What is the ethnic background of the household head?

☐ (0) Masai ☐ (1) Kikuyu ☐ (2) Gabbra
☐ (3) Somali ☐ (4) Kamba ☐ (5) Other, namely ……

9) What is the highest level of education completed by any other member in your household?

☐ (0) Did not go to school ☐ (1) Primary school
☐ (2) Secondary school ☐ (3) College
☐ (4) University ☐ (5) Other, namely ……

10) What is the <u>main</u> occupation in your household?

☐ (0) Farming ☐ (1) Livestock ☐ (2) Dairy
☐ (3) Trading ☐ (4) Artisan ☐ (5) Salaried employment
☐ (6) Casual labor ☐ (7) Other, namely ……

Part 2:

11) How many times <u>per month</u> do you visit this market on average? …… times

12) Which other livestock markets do you visit? …….

12b) If applicable, how often per month on average? …… times

13) How do you travel to the livestock markets?

☐ (0) Walking ☐ (1) Matatu/Shared vehicle ☐ (2) Bicycle
☐ (3) Motorbike ☐ (4) Car ☐ (5) Other, namely ……

14) What is your main reason for visiting this livestock market?

☐ (0) selling ☐ (1) buying ☐ (2) both selling/buying ☐ (3) social ☐ (4) other .....

14b) Buying/selling what? .....

15) How much livestock has your household bought the last 12 months?

..... cows
..... donkeys
..... goats
..... camels
..... pigs
..... sheep
..... poultry

16) How much livestock has your household sold the last 12 months?

..... cows
..... donkeys
..... goats
..... camels
..... pigs
..... sheep
..... poultry

17) How did you pay for the purchase your livestock? (multiple options possible)

☐ (0) cash ☐ (1) credit arrangement ☐ (2) trade ☐ (3) other .....

17b) In case of arrangement, how? .....

18) What do you purchase on this market that is not livestock? (multiple answers possible)

☐ (1) Veterinary drugs ☐ (1) Agricultural tools ☐ (1) Fertilizer
☐ (1) Flashlight / small lights ☐ (1) Lighting fuel ☐ (1) Cooking fuel
☐ (1) Clothing / Cloth ☐ (1) Food ☐ (1) Household Products
☐ (1) Mobile phone credit ☐ (1) Mobile phone charge ☐ (1) Dry cell batteries
☐ (1) Other, namely .....

19) How did you pay for these products? (multiple options possible)

☐ (0) cash ☐ (1) credit arrangement ☐ (2) trade ☐ (3) other .....

19b) In case of arrangement, how? .....

Part 3:

20) How much cattle does your household own?

..... cows
..... donkeys
..... goats
..... camels
..... pigs
..... sheep
..... poultry

21) Does your household own?

- ☐ (1) Bicycle
- ☐ (1) Motorbike
- ☐ (1) Mobile phone
- ☐ (1) Radio
- ☐ (1) TV (if Yes, color tv? ☐ (0) yes ☐ (1) no)
- ☐ (1) Generator
- ☐ (1) Fridge

22) Who in your household makes the decision on: (select from options – if applicable)

☐ (0) Husband	☐ (1) Wife	☐ (2) Joint decision (husband/wife)
☐ (3) **Head**	☐ (4) Mother	☐ (5) Father
☐ (6) **No money spend**	☐ (7) Other, namely ……..	

a) Buying food ……
b) Buying cooking fuels ……
c) Buying fuels for lighting ……
d) Buying household products ……
e) Buying mobile phone credit ……
f) Buying cookstove ……
g) Saving up money for later use ……
h) Small investments (< 1000 Ksh) ……
i) Large investments (> 1000 Ksh) ……

Part 4:

23) What type of cookstove do you use mainly? [Show stove images]

☐ (0) Three stones / open fire [skip Q**24&25**]	☐ (1) U shape, surrounded fire
☐ (2) Metal charcoal stove	☐ (3) Kenya Ceramic Jiko
☐ (4) Upesi / Maendeleo (firewood)	☐ (5) Kuni Bili (firewood / charcoal)
☐ (6) Rocket Stove	☐ (7) other, namely ……..

24) How often do you buy a new stove? every …… years

25) Where do you buy cookstoves?

24a) What kind of shop? ……
24b) Which town? ……
24c) How much did you pay? Ksh ……

26) What is the <u>main</u> fuel you use for cooking?

☐ (0) Firewood [go to **Q26b**]	☐ (1) Charcoal	☐ (2) Kerosene
☐ (3) LPG	☐ (4) Biogas	☐ (5) Sawdust
☐ (6) Other, namely ……		

26b) If you use firewood, how do you acquire the fuel mostly?

☐ (0) Gather ☐ (1) Buy ☐ (2) Other, namely ……

26c) In case of gathering, how many hours do you spend a week? ……

27) How much does your household spend on cooking fuel **per week** on average?

Ksh ……

28) What is the main source of lighting in your dwelling?

☐ (0) Kerosene/oil/gas lamps ☐ (1) Candles ☐ (2) Battery flashlight
☐ (3) Electricity ☐ (4) Solar lamp ☐ (5) No lighting
☐ (6) Other, namely ……

29) How much does your household spend on lighting fuel **per week** on average?

Ksh ……

30) Where do you purchase lighting products?

30a) What kind of shop? ……
30b) Which town? ……
30c) How much did you pay? Ksh ……

Part 5:

Improved cookstoves (ICS)

Improved cookstoves are stoves technologically designed for better performance. They are manufactured out of metal and built to meet standards on efficiency and smoke production. [show cookstove catalogue]

31) Does your household own an improved cookstoves? ☐ (1) Yes [skip Q**32**] ☐ (0) No

32) Do you know anyone (else) that owns an improved cookstoves? ☐ (1) Yes ☐ (0) No

33) Are you aware of the benefits of improved cookstoves? (fill in: I am …… aware)

☐ (0) not ☐ (1) hardly ☐ (2) neutral ☐ (3) moderately ☐ (4) very

34) Are you aware that improved cookstoves: [check off benefits of ICS the respondent knows]

a) reduce fuel use ☐ (0) Yes
b) reduce cooking time ☐ (0) Yes
c) will save time/money acquiring fuel? ☐ (0) Yes
d) may reduce deforestation since less fuel is used? ☐ (0) Yes
e) reduce health impacts? ☐ (0) Yes

Improved Cookstove: Willingness to Pay

In Kenya's rural areas most people rely on biomass as cooking fuel, such as firewood and charcoal. The traditional way of cooking on an open fire with three stones is not efficient: a lot of fuel is used and the smoke that is produced is very harmful to human health. Indoor air pollution is one of the main causes of death in Africa and can cause respiratory diseases and cancer. Woman and small children are most affected, since they spend more time around the cookstove.

This improved cookstove is technologically designed and tested to burn wood in an efficient way. It can reduce fuel use up to 50% and it produces very little smoke. Households that have an improved cookstove spend less time gathering firewood, which means there is more time to work or study, and it also means less trees have to be cut. Moreover, this product is durable, made from metal, and allows you to prepare meals faster. Remember, we are not selling the product – we only want to find out if people would want to use it.

Considering your own household's budget, would you be willing to purchase this product?
> If so, what is the maximum amount you are willing to pay for this product?

I would be willing to pay an amount of Ksh ……..

Ksh 0	Ksh 400	Ksh 1,500	Ksh 5,500
Ksh 140	Ksh 520	Ksh 2,000	Ksh 7,200
Ksh 180	Ksh 680	Ksh 2,500	Ksh 9,200
Ksh 240	Ksh 900	Ksh 3,200	Ksh 12,000
Ksh 300	Ksh 1,200	Ksh 4,200	Ksh > 10,000

35) What is the main reason you would buy an improved cookstove?

Reason: ……
……

36) What is the main reason you would not buy an improved cookstove?

Reason: ……
……

37) Would you be more inclined to buy an improved cookstove through an installment?

☐ (0) very negative ☐ (1) negative ☐ (2) neutral ☐ (3) positive ☐ (4) very positive

38) If you could pay an amount per month for the duration of 12 months, what is the maximum amount you would be willing to pay?

Ksh 0	Ksh 300	Ksh 800	Ksh 2,400
Ksh 140	Ksh 370	Ksh 1,000	Ksh 3,000
Ksh 160	Ksh 460	Ksh 1,300	Ksh 3,600
Ksh 200	Ksh 550	Ksh 1,500	Ksh 4,500
Ksh 250	Ksh 700	Ksh 2,000	Ksh > 4,500

Solar lanterns

Solar lanterns are portable lighting devices that can be charged by sunlight.

39) Does your household own a solar lantern? ☐ (1) Yes [skip Q40] ☐ (0) No

40) Do you know anyone (else) that owns a solar lantern? ☐ (1) Yes ☐ (0) No

41) Are you aware of the benefits of solar lanterns? (fill in: I am …….. aware)

☐ (0) not ☐ (1) hardly ☐ (2) neutral ☐ (3) moderately ☐ (4) very

42) Are you aware that solar lanterns: [check off benefits of ICS the respondent knows]

a) will save time/money acquiring fuel? ☐ (0) Yes
b) gives more light than kerosene or oil lamps? ☐ (0) Yes
c) reduce health impacts? ☐ (0) Yes
d) can often be used to charge mobile phones? ☐ (0) Yes
e) work if there is no electricity ☐ (0) Yes

Solar Lantern: Willingness to pay

Many households in Kenya use kerosene or oil lamps for lighting their houses. These lanterns produce very little light and produce very harmful fumes that contribute to bad indoor air quality. Furthermore, fuel for these lanterns can be expensive.

This solar lantern can give up to 4 hours intense lighting or 8 hours regular lighting on a full battery. The battery is recharged by sunlight – a full charge takes up to 8 hours. Households with solar lanterns do not spend money on lighting fuels such as kerosene, live in a healthier indoor environment and enjoy longer hours with high quality lighting, enabling them to study or work more. Moreover, the lantern can be used for charging mobile phones.

Considering your own household's budget, would you be willing to purchase this product?

If so, what is the maximum amount you are willing to pay for this product?

I would be willing to pay an amount of Ksh ……..

Ksh 0	Ksh 350	Ksh 1,300	Ksh 3,300
Ksh 140	Ksh 450	Ksh 1,600	Ksh 4,200
Ksh 160	Ksh 550	Ksh 2,100	Ksh 5,200
Ksh 220	Ksh 680	Ksh 2,600	Ksh 6,500
Ksh 280	Ksh 850	Ksh 2,600	Ksh > 8,000

43) What is the main reason you would buy a solar lantern?

Reason: ……
……

44) What is the main reason you would not buy a solar lantern?

Reason: ……
……

45) Would you be more inclined to purchase a solar lantern through an installment?

☐ (0) very negative ☐ (1) negative ☐ (2) neutral ☐ (3) positive ☐ (4) very positive

46) If you could pay an amount per month for the duration of 12 months, how much would you be Willing to pay?

Ksh 0	Ksh 300	Ksh 800	Ksh 2,400
Ksh 140	Ksh 370	Ksh 1,000	Ksh 3,000
Ksh 160	Ksh 460	Ksh 1,300	Ksh 3,600
Ksh 200	Ksh 550	Ksh 1,500	Ksh 4,500
Ksh 250	Ksh 700	Ksh 2,000	Ksh > 4,500

47) omitted

48) omitted

Part 6:

Please note:
This is the final part of the questionnaire and will involve questions on income. Please remember this survey is completely anonymous and confidential. We are only looking to collect information. Your responses are important to us and might help us making energy products available in pastoral areas. You will not be contacted after taking part in this research.

49) How many rooms does your house have?

room 1, main activity: ……
room 2, main activity: ……
room 3, main activity: ……
room 4, main activity: ……
room 5, main activity: ……
room 6, main activity: ……

50) Considering the last 12 months: what is your household's average income per month?

☐ (0) < KSH 2,000 ☐ (1) KSH 2,001-5,000 ☐ (2) KSH 5,001-10,000
☐ (3) KSH 10,001-15,001 ☐ (4) KSH 15,001-25,000 ☐ (5) KSH 25,001-35,000
☐ (6) KSH 35,001-45,001 ☐ (7) > KSH 45,000

51) Do you have any savings (money)? ☐ (1) Yes [go to question **51b**] ☐ (0) No

51b) If Yes, how much? Ksh ……

52) Have you ever had a loan? ☐ (1) Yes [go to question **53**] ☐ (0) No [go to question **54**]

53) If Yes, for what purpose? ……

53b) From where? ……

53c) If Yes, for what amount? Ksh ……

54) If No, ever <u>tried</u> to get a loan? ☐ (1) Yes ☐ (0) No

54b) For what purpose? ……

54c) From where? ……

54d) Difficulties? ……

<u>End</u>

Thank you very much for your help. The responses you have given will be kept confidential and anonymous. The results of this research will be used to help the distribution of Renewable Energy Technology in remote areas.

<u>Contact information:</u>
Tom Padding
tel. 070 859 1739

N.B. The questionnaire also included a catalogue of different types of cookstoves, ICS and PSL, for the interviewee to review and help in pointing out with which the respondent was familiar.

Appendix C

t-test: Bissil (0); Suswa (1)					
variable	**Equal variances**	**Bissil**	**Suswa**	**df**	**t**
Gender	Assumed	0.70 (0.463)	0.67 (0.473)	106	0.305
Age	Assumed	36.39 (12.140)	37.38 (11.334)	104	-0.303
Education	Assumed	0.59 (0.734)	0.67 (0.980)	105	-0.474
Family size	Assumed	17.48 (49.561)	14.62 (21.709)	66.298	0.375
No. of children	Not assumed	3.60 (3.326)	5.86 (5.401)	96.460	-2.658*
Household income	Not assumed	9261.36 (10641.892)	14169.64 (14507.765)	97.586	-1.951***
Have savings	Not assumed	0.30 (0.465)	0.43 (0.499)	98.383	-1.298
No. of cows	Assumed	50.46 (129.682)	104.91 (215.700)	106	0.122
No. of goats	Not assumed	81.12 (131.809)	195.07 (329.077)	77.084	-2.421**
Lighting fuels spendings	Not assumed	384.17 (456.214)	225.56 (114.441)	52.260	2.344**
Hours spend gathering firewood	Assumed	5.47 (4.794)	7.46 (6.488)	83	-1.541
Awareness PSL	Not assumed	2.40 (2.029)	2.69 (1.556)	86.097	0.445
WTPics	Assumed	1,340.00 (1,062.155)	1,368.97 (1,093.234)	103	-0.137
WTPpsl	Not assumed	4,883.13 (4,662.039)	1,552.63 (1,229.018)	53.156	4.795***

* Significant at 10% level ** significant at 5% level *** significant at 1% level

Table 7: Two-tailed independent t-test between two locations (SD in parentheses)

Appendix D

t-test: between women (0); men (1)					
variable	**Equal variances**	**women**	**men**	**df**	**t**
Literacy	Not assumed	0.29 (0.462)	0.51 (0.059)	69.735	-2.153**
Education	Not assumed	0.35 (0.597)	0.77 (0.950)	95.738	-2.739*
Distance travelled	Assumed	1.97 (1.446)	2.32 (1.433)	105	-1.151
No. of visits	Assumed	5.00 (2.427)	5.49 (3.461)	106	-0.739
No. of visits to other markets	Assumed	1.24 (1.689)	2.30 (2.536)	106	-2.223**
Awareness ICS	Assumed	2.26 (1.928)	2.33 (1.828)	101	-0.176
Awareness PSL	Assumed	2.00 (1.826)	2.81 (1.734)	96	-2.104**
Decision maker	Assumed	0.75 (0.737)	1.48 (0.646)	72	-4.343*

* Significant at 10% level ** significant at 5% level *** significant at 1% level

Table 8: Two-tailed independent t-test. (SD in parentheses)

Appendix E

t-test: WTP_{psl} < KSh 3,400 (0); WTP_{psl} >= KSh 3,400 (1)					
variable	**Equal variances**	**< KSh 3,400**	**>= KSh 3,400**	**df**	**t**
Gender	Not assumed	37.72 (12.368)	35.15 (9.189)	60.441	0.144
Age	Assumed	0.67 (0.747)	0.74 (0.447)	106	-0.713
Education	Assumed	0.66 (0.885)	0.56 (0.847)	105	0.549
Family size	Not assumed	13.12 (20.015)	24.15 (65.811)	27.726	-0.857
No. of children	Assumed	4.85 (4.899)	4.70 (4.027)	106	0.142
Household income	Assumed	12,952.70 (13,782.600)	9,326.92 (10,806.426)	98	1.215
Have savings	Not assumed	0.40 (0.493)	0.30 (0.415)	48.496	0.977
No. of cows	Assumed	76.65 (187.167)	88.85 (169.857)	106	300
No. of goats	Assumed	147.57 (284.146)	126.56 (519)	106	0.359
Lighting fuels spendings	Not assumed	241.05 (152.539)	473.08 (577.156)	26.204	-2.026*
Awareness PSL	Not assumed	2.46 (1.771)	2.78 (1.867)	44.887	-0.752

* Significant at 10% level ** significant at 5% level *** significant at 1% level

Table 9: Two-tailed independent t-test between two WTP groups (SD in parentheses)

N.B. KSh 3,400 is the retail price of the proxy PSL product.

Appendix F

t-test: Bissil (0); Suswa (1)					
variable	**Equal variances**	**Bissil**	**Suswa**	**df**	**t**
No. of visits to livestock market	Not assumed	7.62 (3.313)	3.36 (0.950)	55.945	8.783***
No. of other livestock markets visited	Assumed	0.60 (0.736)	0.66 (0.579)	104	-0.399
No. of visits to other livestock market	Assumed	1.96 (2.587)	1.97 (2.144)	106	-0.012

* Significant at 10% level ** significant at 5% level *** significant at 1% level

Table 10: Two-tailed independent t-test on livestock market visits between two locations (SD in parentheses)

Appendix G

Correlations

		ICS - WTP	PSL - WTP	ICS - Aware of health improvements	sl_ awareness_ measured	Gender	Education
ICS - WTP	Pearson Correlation	1	,112	,028	,017	-,011	,073
	Sig. (2-tailed)		,259	,779	,870	,915	,462
	N	105	103	101	96	105	104
PSL - WTP	Pearson Correlation	,112	1	,272**	,203*	,118	-,043
	Sig. (2-tailed)	,259		,006	,045	,232	,665
	N	103	105	101	98	105	104
ICS - Aware of health improvements	Pearson Correlation	,028	,272**	1	,479**	-,007	,051
	Sig. (2-tailed)	,779	,006		,000	,942	,612
	N	101	101	103	98	103	102
sl_awareness_ measured	Pearson Correlation	,017	,203*	,479**	1	,210*	,125
	Sig. (2-tailed)	,870	,045	,000		,038	,224
	N	96	98	98	98	98	97
Gender	Pearson Correlation	-,011	,118	-,007	,210*	1	,222*
	Sig. (2-tailed)	,915	,232	,942	,038		,022
	N	105	105	103	98	108	107
Education	Pearson Correlation	,073	-,043	,051	,125	,222*	1
	Sig. (2-tailed)	,462	,665	,612	,224	,022	
	N	104	104	102	97	107	107

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 11: SPSS results correlation study

Appendix H

Calculation for turning point:

$$WTP_{psl} = \alpha_{age} + \beta_{age}{}^{2}$$

so that:

$$\frac{dWTP}{dage} = \propto + \beta_{age}$$

to find the turning point we consider:

$$\frac{dWTP}{dage} = 0$$

so:

$$223.127 - 2 \times 3.509 \times age = 0$$

$$age = 31.79$$

This means the turning point in the relation between WTP_{psl} and age lies at the age of 31.79.